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RECENT STUDIES OF THE MARTIAN AND LUNAR CANALS.

WILLIAM H. PICKERING.

For Popular Astronomy.

It has lately been shown by Messrs. Lane, Maunder, and Evans that many of the finer Martian canals are probably non-existent, their appearance being due to certain singular optical illusions. Most of the broader canals however, in the dark regions of the planet, undoubtedly exist, and the same is almost certainly true of some of those in the light regions, such as *Nilosyrtis* and *Nectar*. The chief cause of the illusion seems to be the system of lakes, or oases as they are sometimes called, which were first discovered in large numbers at Arequipa. There is a curious tendency of the human eye to see such dark points united by faint narrow lines, and it has been shown by means of diagrams that these lines sometimes appear when the diagram is at such a distance that the dark dots are themselves invisible. But even without the dots the lines may sometimes appear, joining different portions of the dark regions. We must therefore divide the Martian canals into two classes, those that are genuine and those that are not.

Any canal that appears first as a broad streak of measurable breadth, and then gradually narrows as the season progresses may be classed as genuine, although its image may appear by illusion long after the canal itself has really gone. This narrowing of the canals, especially in the dark regions, is very common after the passage of the vernal equinox on Mars. It is also true of several of the canals in the region about *Solis lacus*. Any canal on the contrary which suddenly appears as a faint narrow line joining two dark regions must in the future be looked upon with suspicion, even if to the trained eye it is fairly well seen. To this class perhaps belong such conspicuous and well known examples as *Phison*, *Gehon* and *Euphrates*, besides very many other less observed canals.

This phenomenon of spurious canals is certainly very singular, but we must be careful that its interest and unexpectedness do not lead us into the error of affirming that because many Martian canals are spurious, therefore all Martian canals are imaginary. It seems indeed a great pity that so much time and energy should have been expended in many observatories in mapping canals in the bright regions of the planet, and comparatively so little time spent on the darker regions, where changes are constantly taking place, and where we should naturally expect the more interesting developments to occur.

Turning now to the other branch of our subject, we find upon the Moon, where the surface conditions are in some respects similar to those upon Mars, although the atmosphere is probably rarer, numerous canals, which on account of their proximity are much more readily studied than the Martian ones. While from the Harvard station in Southern California photographs of Mars were secured showing the *Syrtis major*, the *Fastigium Aryn*, and other prominent markings, no one has as yet succeeded in photographing fine enough detail to show a Martian canal. On the Moon, on the other hand, a few canals have already been photographed, both at Arequipa and in Jamaica. Recently a fine photograph has been received through the kindness of Professor Hale, which shows several of the canals to much better advantage than any photograph previously taken. Indeed, it may be said that these latest views taken with the Yerkes telescope show nearly all the detail visible with a 6-inch telescope working under very favorable conditions.

For purposes of comparison, I have placed in the frontispiece a drawing of the canals about Eratosthenes, made in Jamaica, and published in my recent book on the Moon, and an enlargement to the same scale of the same region shown in the Yerkes photograph. The scale is $\frac{1}{2{,}000{,}000}$, or about 32 miles to the inch. The drawing was made August 1, 1901, at 8.6 days after sunrise on Eratosthenes, colongitude of the sunrise terminator 116°. It has been impossible to learn the date when the photograph was taken, excepting for the fact that it was taken recently. A comparison with the Harvard photographs shows that its colongitude must be in the vicinity of 140°, which would be about eleven and a half days after sunrise. Whilst therefore the photograph was taken about three days later in the lunation than the drawing, we still find that no very marked changes have occurred in the mean time. Since the drawing was made

only 1.7 days after full moon, when the Sun was nearly in the zenith of the crater, and since the same markings are found on other drawings and photographs made at and before full moon, it will be seen that it is geometrically impossible that these markings should be due to shadows. They represent therefore real differences in surface coloration and nothing else.

We may designate a canal on the drawing by its distance in inches and tenths from the left hand edge and from the bottom of the picture. The V-shaped central peaks are easily recognized in both views, and their inferior size in the drawing shows one of its most obvious defects. The dark canal 1.6, 1.5 in the drawing is very pronounced in the photograph, while the one at right angles to it is well shown. The two other canals centering in the lake 1.5, 1.6 do not quite reach it in the photograph, but appear as one faint, continuous sinuous line. This may be a change, such as frequently occurs upon Mars, and is not necessarily a defect in the drawing. The tendency to draw as straight lines, canals, which are really made up of curves has often been suspected upon Mars. We have a very good illustration of this in the case of the canals to the right of the two bright spots 1.8, 1.3, and 1.9, 1.4. The photograph shows that instead of being straight as drawn, these canals are in reality markedly curved.

The dark spot 1.5, 0.9 appears of quite another shape in the photograph. While in Jamaica it was noticed that this spot was constantly changing its shape, I am not inclined therefore to ascribe this difference in appearance to a defect in the drawing. I am not so sure however regarding the markings just to the right of this spot, which are complicated in structure, and rather difficult to carry in one's mind, while looking back and forth from the telescope to the paper. Some of my other drawings of this region look more like the photograph, and this difference may therefore be due to defective drawing. The fading out of the canal 1.0, 0.9 is well shown in the photograph. A day or two later in the lunation it had entirely disappeared.

Other points of resemblance and of difference in the drawing and photograph might be discussed, but enough have already been shown to prove that lunar photography has at last reached a point where it may be used to check and correct drawings of even the finer detail upon the Moon.

The other photograph is an enlargement from the same original negative to the same scale. The region shown is situated four diameters south, 20° west, from Eratosthenes. The dark region at the top is in fact the site of Gruithuison's celebrated ruined

lunar city. He described a central street from which five or six parallel streets led off on either side at an angle of 45°, like the veins of a leaf. Something of the same sort has been seen by several other observers, and I have myself seen a few of the lines. The so-called streets are apparently a difficult and very curious combination of ridges. What interests us most however, is a series of well marked canals near the center of the view. Just below the center is a white spot. In this is located a Y-shaped combination of canals. From near the foot of the Y a canal leads off to the right, to a very dark spot. This canal is fourteen miles long, and about half a mile in breadth. A short canal branches off from its upper side, i. e., towards the south, and other canals lead off from the dark spot. Below and to the left of this spot is another one of about the same size. Both are suspected of changing the finer details of their shape in the course of the lunation.

In my recent researches I have found, and have endeavored to show, that there is a wealth of fine detail upon the Moon, exhibiting constant variations, of the highest interest to the intelligent selenographer. Of these variations, many it is believed are periodic, while some are wholly irregular in their character. To see them does not involve the use of a large telescope, but it does require a good atmosphere, and also a knowledge of the kind of variations one may expect to observe, and of the sort of places in which they are likely to occur. Without this knowledge much time may be wasted in studying unfavorable localities.

January 4, 1904.

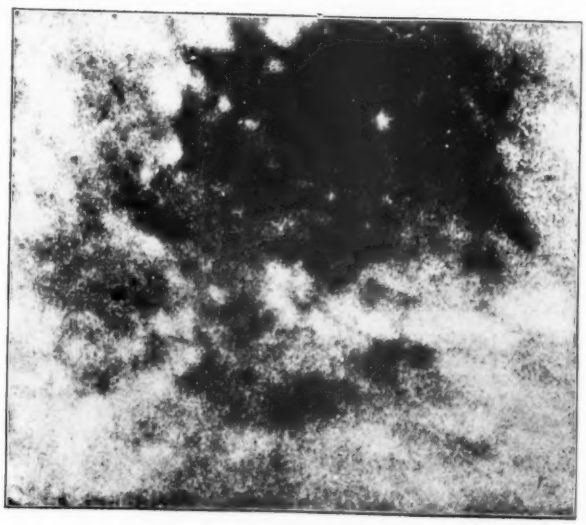
A NEW LIFE OF GALILEO.

HERBERT A. HOWE.

For Popular Astronomy.

In the year 1890 there was published at Florence the first volume of a work entitled "Le Opere di Galileo Galilei-Edizione Nazionale sotto gli auspicii di S. M. il Re d' Italia." Each ensuing year has witnessed the publication of another volume of this monumental work, which is under the editorship of Professor Antonio Favaro of the Royal University of Padua, and which is to be completed in twenty volumes. Upon this Professor Favaro has spent twenty-five years of research. Fortunately for English and American readers he has generously placed all his Galilean studies at the disposal of Mr. J. J. Fahie, so that the latter has

PLATE VI



REGION NEAR ERATOSTHENES.

been enabled to produce a biography of Galileo,* which is by far the most extensive and accurate in our language. It contains many quotations from Galileo's writings, which are of such interest that the readers of POPULAR ASTRONOMY may be glad of the opportunity of perusing a few of them.

1. *The Invention of the Telescope.* In the summer of 1609 a report reached Venice that "a Dutchman had presented to Count Maurice of Nassan a glass by means of which one could see distant things as clearly as if they were near." Galileo, hearing this, began to study over the matter, and succeeded in re-inventing the instrument. The method by which he made the re-invention is set forth in "Il Saggiatore," from which we take the following extract.

"Thus we are certain that the Dutchman, the first inventor of the telescope, was a simple spectacle maker, who, handling by chance different forms of glasses, looked, also by chance, through two of them, one convex and the other concave, held at different distances from the eye; saw and noted the unexpected result; and thus found the instrument. On the other hand, I, on the simple information of the effect obtained, discovered the same instrument, not by chance, but by the way of pure reasoning. Here are the steps: the artifice of the instrument depends either on one glass or on several. It cannot depend on one, for that must be either convex, or concave, or plain. The last form neither augments nor diminishes visible objects; the concave diminishes them, the convex increases them, but both show them blurred and indistinct. Passing then to the combination of two glasses, and knowing that glasses with plain surfaces change nothing, I concluded that the effect could not be produced by combining a plain glass with a convex or a concave one; I was thus left with the two other kinds of glasses, and after a few experiments I saw how the effect sought could be produced. Such was the march of my discovery, in which I was not assisted in any way by the knowledge that the conclusion at which I aimed was a verity.

"But some people believe that the certainty of the result aimed at affords great help in attaining it. Let them read history, and they will find that Archites made a dove that could fly, and that Archimedes made a mirror that burned objects at great distances, and many other admirable machines. Now, by reasoning on these things such people, doubtless, will be able, with very little

* Galileo, His Life and Work, by J. J. Fahie; published by James Pott & Co.; $5.00.

trouble, and with great honor and advantage, to tell us how they were constructed. And even if they do not succeed they will be able to certify for their own satisfaction that that ease of fabrication which they had promised themselves from the foreknowledge of the result is very much less than what they had imagined."

2. *The Bigotry of Professed Men of Science.* It is well known that the discoveries made by Galileo with his "optic tube" did not meet with immediate favor in the minds of most of the distinguished occupants of the professorial chairs of the foremost universities of Europe.

Clavio, of Rome, a mathematician of considerable repute, scoffed at the idea that Jupiter had four moons, and intimated that Galileo had put artificial satellites inside of his telescope. In reply Galileo offered 10,000 scudi to any one who would accomplish such a mechanical and optical feat. Of this mathematician, and others of like ilk Galileo wrote to Kepler under date of Aug. 19, 1610, as follows:

"What do you say of the leading philosophers here to whom I have offered a thousand times of my own accord to show my studies, but who, with the lazy obstinacy of a serpent who has eaten his fill, have never consented to look at the planets, the Moon, or telescope? Verily, just as serpents close their ears, so do men close their eyes to the light of truth. To such people philosophy is a kind of book, like the Æneid or Odyssey, where the truth is to be sought, not in the universe or in nature, but (I use their own words) by comparing texts! How you would laugh if you heard what things the first philosopher of the faculty at Pisa brought against me in the presence of the Grand Duke. He tried hard with logical arguments, as if with magical incantations, to tear down and argue the new planets out of heaven!"

As a specimen of the logic with which the opponents of Galileo tried to overwhelm him we quote from the *Dianoia Astronomica* of Francesco Sizzi, an astronomer of Florence:

"Moreover, these satellites of Jupiter are invisible to the naked eye, and therefore can exercise no influence on the Earth, and therefore would be useless, and therefore do not exist. Besides, the Jews, and other ancient nations, as well as modern Europeans, have adopted the division of the week into seven days, and have named them after the seven planets. Now if we increase the number of the planets, this whole and beautiful system falls to the ground."

3. *The Rings of Saturn.* At first Galileo saw this planet as a

triple object consisting of one central body flanked by two smaller ones, which gradually diminished and finally vanished, to his great amazement and confusion. Arago concluded that Galileo was so disheartened by this phenomenon that he did not observe the planet further. But this conclusion is wide of the truth. Not only did Galileo see the two attendants of Saturn reappear, but he even drew pictures which plainly show that he noticed the dark space between the ball and what we now know to be the rings. In looking at the facsimiles of some of these sketches in Mr. Fahie's book one is astonished that Galileo did not discover that a ring surrounded the central ball. Professor Favaro has found in the Ambrosian Library at Milan a letter written to Prince Cesi by Galileo, in which occurs the following passage:

"I cannot rest without signifying to your Excellency a new and most strange phenomenon observed by me in the last few days in Saturn. Its two companions are no longer two small and perfectly round globes, as they have hitherto appeared to be, but are now bodies much larger, and of a form no longer round, but as shown in the annexed figure, with the two middle parts obscured, that is to say, two very dark triangular-like spaces in the middle of the figure and contiguous to the middle of Saturn's globe, which latter is seen, as always, perfectly round."

Twenty-four years afterward, when Galileo had been blind for three years, he summed up his observations of Saturn in the language below:

"When first I observed Saturn he was composed of three round stars, situated in a straight line from *Ponente* to *Levante*, of which the central was much larger than the lateral ones. Thus I continued to see him for some months. Then, after an interval of some more months, I again examined him and found him solitary, i. e. the great central star was only to be seen. Amazed at this result, and supposing it to be due to some kind of change, I ventured to say that in five or six months, i. e. at the summer solstice, the two small lateral stars would reappear. They did, and so I saw them for a long time after. Then after another interval, during which Saturn was masked by the Sun's rays, I again observed him, and now saw him with two mitres, instead of round stars, which gave him the figure of an olive. I saw the central globe very distinctly, and two very dark spots in the middle of the attachment of the mitres, or, as one may say, the ears. So I observed him for many years; and now your Reverence writes (as also other of my friends) that the mitres are transformed into two small globes. It may be that in the last three

years, during which I have been unable to make any observations, Saturn may have become once again solitary, and then later on may have returned to the form in which I at first observed him. It will be for the future and for others to make observations, registering the times of mutation so as to accurately determine their periods—that is, if there will be any persons curious enough to do what I, from the same motive (not knowing how to do better), have done for so long a time."

4. *The Bible and Science.* One day in December, 1613, there was a dinner party at Pisa, and the Professor of Physics in the University of that city, in a conversation with the Dowager Duchess of the Tuscan Court, assured her that the doctrine of the double motion of the Earth, which was powerfully reinforced by Galileo's discoveries, was contrary to Scripture. Castelli, the Professor of Mathematics in the same University, was called in to defend Galileo, and afterwards apprised the latter of the discussion. In a few days Galileo wrote to Castelli a letter setting forth his views of the relation between Scripture and Science. This letter, which was indiscreetly published by Castelli, hastened the coming of the day when Galileo was brought to an accounting for his supposed heresies. Mr. Fahie gives the following quotation from this letter:

"As the Bible, although dictated by the Holy Spirit, admits (for the reasons given above) in many passsages of an interpretation other than the literal one, and as, moreover, we cannot maintain with certainty that *all* interpreters are inspired by God, I think it would be the part of wisdom not to allow any one to apply passages of Scripture in such a way as to force them to support as true any conclusions concerning nature, the contrary of which may afterwards be revealed by the evidence of our senses, or by actual demonstration. Who will set bounds to man's understanding? Who can assure us that everything that can be known in the world is known already? * * * I am inclined to think that Holy Scripture is intended to convince men of those truths which are necessary for their salvation, and which being far above man's understanding cannot be made credible by any learning, or by any other means than revelation. But that the same God who has endowed us with senses, reason, and understanding, does not permit us to use them, and desires to acquaint us in another way with such knowledge as we are in a position to acquire for ourselves by means of those faculties—*that*, it seems to me I am not bound to believe, especially concerning those sciences about which the Holy Scriptures contain only small frag-

ments and varying explanations; and this is precisely the case with astronomy, of which there is so little that the planets are not all enumerated, only the Sun and Moon, and once or twice Venvs under the name of Lucifer. This, therefore, being granted, I think that in discussing natural phenomena we ought not to begin with texts from Scripture, but with experiment and demonstration, for from the Divine Word Scripture and Nature do alike proceed. And I can see that that which experience sets before our eyes concerning natural effects, or which demonstration proves unto us, ought not upon any account to be called in question, much less condemned, upon the testimony of Scriptural texts, which may (under their mere words) have meanings of a contrary nature."

5. *Experiment contrasted with Logic.* In the year 1619 appeared a pamphlet in abuse of Galileo's views; it was written by Grassi, a Jesuit Father, under the pseudonym of Lotario Sarsi. In this pamphlet Grassi had used as an argument in behalf of his own views a ridiculous story about the Babylonians. With keen irony Galileo replied as follows:

"If Sarsi insists that I must believe, on Suidas's credit, that the Babylonians cooked eggs by swiftly whirling them in a sling, I will believe it; but I must say, that the cause of such an effect is very remote from that to which it is attributed, and to find the true cause I shall reason thus: If an effect does not follow with us which followed with others at another time, it is because, in our experiment, something is wanting which was the cause of the former success; and if only one thing is wanting to us, that one thing is the true cause. Now we have eggs, and slings, and strong men to whirl them, and yet they will not become cooked; nay, if they were hot at first they more quickly become cold; and since nothing is wanting to us but to be Babylonians, it follows that being Babylonians is the true cause why the eggs became cooked, and not the friction of the air, which is what I wish to prove. Is it possible that in traveling by post, Sarsi has never noticed what freshness is occasioned on the face by the continual change of air? And if he has felt it, will he rather trust the relation by others of what was done two thousand years ago at Babylon, than what he can at this moment verify in his own person? I, at least, will not be so wilfully wrong, and so ungrateful to nature and to God, that having been gifted with sense and language I should voluntarily set less value on such great endowments than on the fallacies of a fellow-man, and blindly and blunderingly believe whatever I hear, and barter the freedom of my

intellect for slavery to one as liable to error as myself."

6. *The Manipulation of a Microscope.* In 1612 Galileo presented a microscope to the King of Poland. Two years later the Canon of the Cathedral of Sarlat visited the great philosopher; of this visit he said:

"Galileo told me that the tube of a telescope for observing the stars is no more than 2 feet in length; but to see well objects, which are very near, and which on account of their small size are hardly visible to the naked eye, the tube must have two or three lengths. He tells me that with this long tube he has seen flies which look as big as a lamb, are covered all over with hair, and have very pointed nails, by means of which they keep themselves up and walk on glass, although hanging feet upwards, by inserting the points of their nails in the pores of the glass."

In 1624 Galileo sent a microscope to Prince Cesi, with the following explanation of the method of using it:

"I send your Excellency a little spy-glass for observing at close quarters the smallest objects, which I hope will afford you the same interest and pleasure that it does to myself. I delayed sending it because my first specimens were imperfect by reason of the difficulty in fashioning the lenses. The object is placed on a movable circle (at the base of the instrument) which can be turned in such a way as to show successive portions, a single pose being unable to show more than a small part of the whole. As the distance between the lens and the object must be precisely adjusted in order to see things that are in relief, it is necessary to bring the glass nearer to and farther from the object, according to the parts to be examined. Therefore the little tube is made adjustable on its stand or guide. The instrument should be used in a strong light, or even in full sunlight, so as to illuminate the object as much as possible.

"I have examined with the greatest delight a large number of animals, amongst which the bug is most horrible, the gnat and the moth very beautiful. I have also been able to discover how the fly and other little animals are able to walk on window-panes and ceilings feet upwards. But your Excellency will now have the opportunity of observing thousands of other details of the most curious kind, of which I shall be glad to have an account. In short one may contemplate endlessly the grandeur of Nature, how subtilely she works, and with what unspeakable diligence.

"P. S.—The little tube is in two pieces, so that you may lengthen it or shorten it at pleasure."

It is evident that if Galileo could step into a modern biological

laboratory he would at once be at home with a compound microscope.

7. *Galileo's daughter, Maria Celeste.* The picture of the later years of Galileo's life is a very sombre one, because of his sufferings from disease and persecution. His hours of pain and gloom were blessed by the loving devotion of his eldest daughter, the nun Maria Celeste, whose correspondence with her father was carefully preserved by him, and evinced her love and care in a striking manner. The other nuns might have their patron saints, in whom they confided. But the name of her patron saint was not found in any Calendar of the Church: she was a "*Devoto*" of her own father, and he of her. Her piety and devotion are well set forth in a letter written at a time when she thought him in danger from a virulent plague which was rife within the city.

"I believe that you have by you all the remedies and preventives that are required, so I will not repeat. Yet I would entreat you, with all reverence and confidence, to procure one more remedy—the best of all, to wit, the grace of God, by means of true contrition and penitence. This is without doubt the most efficacious remedy both for soul and body. For, if in order to avoid this sickness it is necessary to be always of good cheer, what greater joy can we have in this world than the possession of a good and serene conscience? * * * I pray your Lordship to accept these few words prompted by the deepest affection.

"I wish also to acquaint you with the frame of mind in which I find myself at present. I am desirous of passing away to the next life, for every day I see more clearly the vanity and misery of this present one. There I would hope that my prayers for your Lordship would have greater efficacy."

8. *Galileo before the Inquisition.* So much has been written on this subject by the friends and by the foes of the Roman Church that it seems quite difficult to form a just opinion concerning many of the details of the matter. Though Mr. Fahie evidently sympathizes with Galileo in the sore trials to which he was subjected in the course of his long and painful conflict with the ecclesiastical authorities, he has endeavored to look at both sides of the affair, and to put a fair interpretation upon the evidence in hand. The sentence of the Inquisition,—read to Galileo on June 22, 1633 in the presence of a large assembly of cardinals and prelates—is given in full and covers several pages. The burden of it is that Galileo was ordered nearly twenty years before to abstain from holding and teaching the false doctrine of the double motion of the Earth, and that he had disobeyed these

orders. In consequence of this disobedience the following sentence was passed upon him:

* * * "Invoking, therefore, the most holy name of our Lord Jesus Christ, and of His Most Glorious Virgin Mother, Mary, We pronounce this Our final sentence, which, sitting in council and judgment with the Reverend Masters of Sacred Theology and Doctors of both Laws, Our Assessors, We put forth in this writing in regard to the matters and controversies between the Magnificent Carlo Sincero, Doctor of both Laws, Fiscal Proctor of the Holy Office, of the one part, and you, Galileo Galilei, defendant, tried and confessed as above, of the other part, We pronounce, judge, and declare, that you, the said Galileo, by reason of these things which have been detailed in the course of this writing, and which, as above, you have confessed, have rendered yourself vehemently suspected by this Holy Office of heresy, that is of having believed and held the doctrine (which is false and contrary to the Holy and Divine Scriptures), that the Sun is the center of the world, and that it does not move from east to west, and that the Earth does move, and is not the center of the world; also, that an opinion can be held and supported as probable, after it has been declared and finally decreed contrary to the Holy Scripture, and, consequently, that you have incurred all the censures and penalties enjoined and promulgated in the sacred canons and other general and particular constitutions against delinquents of this description. From which it is Our pleasure that you be absolved, provided that with a sincere heart and unfeigned faith, in Our presence, you abjure, curse, and detest, the said errors and heresies. and every other error and heresy, contrary to the Catholic and Apostolic Church of Rome, in the form now shown to you.

"But that your grievous and pernicious error and transgression may not go altogether unpunished, and that you may be made more cautious in future, and may be a warning to others to abstain from delinquencies of this sort, We decree that the book 'Declogues of Galileo Galilei' be prohibited by a public edict, and We condemn you to the formal prison of this Holy Office for a period determinable at Our pleasure; and by way of salutary penance, We order you during the next three years to recite, once a week, the seven penitential psalms, reserving to Ourselves the power of moderating, commuting, or taking off, the whole or part of the said punishment or penance." * * *

After the sentence had been pronounced Galileo was compelled to kneel before the assembled company, and to make a complete

and humiliating abjuration, The decree of 1616 prohibiting all books which teach the Copernican doctrine stood until 1822, when it was resolved "that the printing and publication of works treating of the motion of the Earth and the stability of the Sun, in accordance with the opinion of modern astronomers, is permitted in Rome." Not till 1835 was Galileo's name removed from the Index Expurgatorius.

Mr. Fahie holds the view that Galileo was not subjected to the torture of the rack, and was not thrown into a dungeon of the Inquisition; also that the story that he altered the words "Eppur si muove" at the conclusion of his abjuration is utterly improbable. Galileo expressed an opinion as to the cause of his troubles with the Church in a letter to Diodati, written about a year after his abjuration.

"Thus, about two months ago when a dear friend of mine at Rome was speaking of my affairs to Father Cristoforo Griemberger, mathematician at the *Collegio Romano*, this Jesuit uttered the following precise words: 'If Galileo had only known how to retain the favor of the fathers of this college he would have stood in renown before the world, he would have been spared all his misfortunes, and could have written all he pleased about everything—even about the motion of the Earth.' * * * A certain Jesuit father has printed at Rome that the opinion of the motion of the Earth is of all heresies the most abominable, the most pernicious, the most scandalous; and that one may maintain in professorial chairs, in society, in public discussions, and in books, any and every argument against the principal articles of faith, against the immortality of the soul, against the creation, against the Incarnation, against everything, with one exception only—the dogma of the immobility of the Earth!"

CHAMBERLIN OBSERVATORY,
University of Denver.

RECENT ASTRONOMICAL RESEARCH.

WM. W. PAYNE.

It is our aim, each month, in a general way, to call attention very briefly to some of the more prominent lines of original astronomical work, in regard to plans, methods or results, or, in any other respect, which may seem to be very useful to those interested in astronomy. Photography has come into such general use in some branches of the science, that we now wonder that

this very efficient aid in astronomical research had not been put in place of service long ago. The great star charts of the heavens, the observations of Eros, the work on nebulæ and comets are some of the important lines of work in which photography works especially well.

Harvard College Observatory in Cambridge and at its station in Peru has done, in the last few years, a vast amount of astronomical work by the aid of photography chiefly. In Professor E. C. Pickering's last report is found a brief statement in this regard that is well worth copying, for the general reader. It is as follows:

"The problem of obtaining the greatest return for astronomical science from a given expenditure of money should be the principal concern of every astronomer. It is obvions that no single observatory can accomplish as much and as good work as could be done through the efforts of the entire astronomical world. The recent attempt on the part of this Observatory to secure an endowment for international astronomical research has led certain persons to infer that the present needs at Harvard are supplied. An important part of this very plan is to enable a large Observatory like this, which can undertake to great advantage large pieces of routine investigation quite beyond the reach of the smaller observatories, to use its resources to the best advantage. It can coöperate with others, and thus bring the energy of many minds to bear upon a single problem. As an illustration, it is recognized that the distribution of the stars in space is one of the most important problems in astronomy. This investigation depends on the accurate measures of the light of stars in all parts of the sky. But little work of this kind has been done on the light of the southern stars. Especial attention has been paid to photometry at this Observatory, and we have an excellent southern station where such work could be carried on to great advantage. An expenditure of one thousand dollars annually for five years would go far to provide for this want; but as the expenses here for the last year have exceeded the income, additional work cannot be undertaken. Again, the Harvard collection of astronomical photographs gives the history of the stellar universe for the last fourteen years with a completeness not attempted elsewhere; but these photographs are of little use unless a careful study is made of them. A satisfactory plan has been prepared for organizing a corps of observers at a cost of about five thousand dollars a year, for studying these photographs. The Carnegie Institution appropriated $2,500 last year for this work,

but gave no assurance that it would be increased, or even continued. Results have already been obtained which show what might be expected from a permanent maintenance of this work; but if the appropriation is not continued much work will be lost, and may assistants who have been carefully trained will be obliged to seek work elsewhere. The great increase in the resources of the Observatory has not been accompanied by a similar increase in the amount of capital available for plant. Accordingly, the buildings and instruments here, purchased mainly from income, are very inferior to those of other observatories whose endowment is much less. The anonymous gift of 1902 has been of the greatest service in this respect, since it will provide two reflectors of twenty-five inches aperture, one for use on the northern, and the other on the southern stars, and has given us a fireproof wing to the building already used for storing and studying the photographs. The cost of the entire building and wing was only about $20,000, and two similar buildings would provide for a much needed new library for the Observatory, computing rooms, photographic laboratory, and a workshop. All of this work is now carried on in very inferior wooden buildings, some of them more than half a century old. Much money is also spent in strengthening floors and repairing foundations; and the danger from fire is ever present.

If the sum of $50,000 could be expended during the next ten years for such researches and buildings as those mentioned above, it is believed that a relatively large return in scientific results would be obtained. Our expenses now slightly exceed our income, and if they are cut down, a proportionately greater diminution in work will ensue. An unrestricted fund like that mentioned above would permit our present appliances to be used to the best advantage. Whatever may be the future of the Observatory, there is no doubt that a reasonable sum could be wisely expended at once, while a delay of several years may bring other conditions less favorable to effective expenditure, and will certainly cause some needs to be neglected which now seem most urgent."

Another piece of excellent photographic work is found in the new book prepared by Professor William H. Pickering of Harvard College Observatory, titled, The Moon. This volume is a summary of the existing knowledge of our satellite with a complete photographic atlas; it is published by Doubleday, Page and Company of New York, the net price being ten dollars. The description of this book consists of thirteen chapters, embracing

103 pages, large size, with wide margin; very fully illustrated with drawings and half-tone cuts, interspersed in the reading matter.

In the text the author considers the origin of the Moon; its rotation, distance, orbit, light, libration gravitation; atmosphere, water, temperature; origin of the lunar craters; illustrative artificial craters; origin of the various formations; active lunar craters, river-beds; ice on the Moon, the bright streaks; vegetation, the lunar canals; recent investigations; fancies, apparent size, suppositions, influence on the weather; history of lunar research; the photographic atlas, the map of the Moon, and lunar altitudes.

In his treatment of these themes, the author has passed by almost all the common-place information found in the ordinary text-books of astronomy, and has presented the latest phases of study known to the modern selenographer in plain and untechnical language. This fact alone makes the book a very useful one for the popular reader, the student and the professional scientist as well.

It may be known to some of our readers that the author of this new volume recently had charge of a party from Harvard College Observatory which went to Jamaica, and there made a very complete and valuable set of Moon photographs. These have been related and arranged to form the atlas before referred to. In planning how to take the photographs, it was decided to divide the diameter of the Moon, east and west, into eight equal parts and erect perpendiculars at the dividing points which gave in all sixteen regions. Of each of these divisions five photographs were taken, making eighty in all, which covered the entire, visible surface of the Moon five times. The views for each region are, one at lunar sunrise, one two days after sunrise, one at lunar noon; another two days before lunar sunset and the last at lunar sunset. The manifest advantage of this plan is, that it shows the same objects on the Moon's surface, at least, under five different phases of illumination, to say nothing about some of the overlapping parts of the plates which appear as many as ten times in the series. This fact suggests a pretty severe test on the skill of the artist to get all parts of these Moon pictures so well in the focus of his instrument that one does not notice obtrusive lack of definition in any. It appears to the writer that not all the pictures are equally sharp or equally good; but the wonder is that there are not greater differences in merit among so many taken within a period of seven months.

In these photographs the author has also avoided a fault which appears in so many pictures of the Moon which have been greatly enlarged from the original negatives. Sometimes this work of enlargement has been carried so far as to make the granular structure of the film of the original negative stand out harshly even in the finest prints that can be made. Such a glare is unnatural and is always disappointing to those who rightly expect the soft, continuous finish of a photographic film that will differentiate, in detail, most beautifully and almost perfectly, when it is not overworked.

The appearance is that these good results could not have been realized without an instrument giving a wide, flat, photographic field, and it is interesting to know how this end was accomplished. From the descriptive part of the photographic atlas it is learned that a twelve-inch objective with a photographic focus of 135 feet and 4 inches was mounted on the side of a hill with inclination of about 30°. The upper end of this long tube came into a second story of a building where the observations were made. At the lower end of it was the objective and a mirror 18 inches in diameter, used as a reflector to throw the light of the Moon through the objective and the long tube to its eye-end. By means of electric motors the mirror and the plate-holder were made to revolve, so as to neutralize the rotation of the Earth on its axis. It is said, by the author, that this novel means of controlling the mirror and the photographic plate, in actual use, worked very well. A good objective of this kind, handled in this way, ought to do fine work.

As an illustration of how the photographs were prepared for the atlas, we will cite one instance which was the first step in constructing the author's map of the Moon. The negative of the full Moon finally chosen was taken, at Jamaica, on the night of Aug. 29, 1901 $16^h\ 50^m$ G. M. T. The image measured 15.7 inches in diameter

It was enlarged on bromide paper to a diameter of about 27.7 inches. The craters, parallels and meridians were then inserted. When completed the map was reduced by photography to an approximate diameter of 13.7 inches, which is just one ten-millionth of the diameter of the Moon. This would give a scale, measured on the Moon's axis of about 160 miles to the inch.

It would be profitable to our readers to take up the themes presented by the author in this new book, and give somewhat in detail the new things therein said in connection with each, but this would carry us too far from the object of this already extended

notice of this popular work. It will suffice to say that Professor W. H. Pickering has made a most valuable and timely contribution to the literature of the Moon, by the aid of the best modern methods of research. The fact that the book has been written entirely in popular language is one of the best things about it. Intelligent popular readers will find it the best reference book for late knowledge of the Moon in connection with any good text-book on the subject that we know of.

The author calls our attention to the following errata:

Page 32, line 31, for 5.7 read 5.6. Page 37, line 18, for (64,159) read (2.5, 6.3). Page 37, line 25, Plate 3B is inverted. These measures should therefore be made from the left and top. Page 37, line 29, for 6.3 read 6.2. Page 37, line 31, for 6.6 read 6.5. Page 39, line 5, for 4.1 read 4.2. Page 43, line 16, for 8 read δ. Page 49, line 19, for B read C. Page 49, line 25, for Messier, A read Messier A. Page 52, line 2, see page 37, line 25, above. Plate F. The straight dark lines on Figures 6 and 7 are defects. Figure 7 should be turned one-quarter way round, so as to resemble Figure 8. Page 68, line 18, for 33, read 13. Page 70, line 27, for 3B (1.2, 8.5) and 3E (1.1, 8.6) read 2A (3.2, 1.2) and 2C (3.2, 1.8). Page 70, line 28, for 5 and 8 read 3 and 6. Plate H, last line, for 22 read 2. Page 103, line 1, for contents read constants. Plate 3B. This plate is inverted.

JESUIT ASTRONOMY.* II.

JOHN SCHREIBER, S. J.†

FOR POPULAR ASTRONOMY.

Observations.

If we ask what the Jesuits have observed, the self-evident answer is: Very much. This is warranted by the many publications in which the current observations are communicated. Thus, for example, Fr. Maximilian Hell in Vienna edited the ephemerides from 1757 until 1795. and Fr. Triesnecker from 1794 until 1806. These, besides the numerical which is the essential, but at the same time the most laborious part of the ephemerides, alway contain an appendix of the observations made in the course of the year. Besides these Hell also issued about thirty separate publications, Triesnecker 7.—The like is true of Fr. Francis Weiss in Tyrnau, who published the observations from

* Continued from page 20.

† "Die Jesuiten des 17. und 18. Jahrhunderts und ihr Verhältnis zur Astronomie" by Johann Schreiber, S. J., Assistant Astronomer at the Haynald Observatory, Kalocsa, Hungary. *Natur* und *Offenbarung*, Vol. 49, 1903.—Translated by William F. Rigge, S. J., Creighton University Observatory, Omaha, Neb.

1756 to 1770; the last years being by Fr. Francis Taucher. For the rest a glance at Riccioli's Almagest is sufficient to show what a busy life the Jesuit astronomers lived. Where he speaks of eclipses, for instance, he mentions very many Jesuits who took part in the observations, and gives the manner of observing used by each and the result. In order to give prominence to only one eclipse: for the lunar eclipse of April 14, 1642, he mentions the following places (I omit the names and remarks): Mantua, Trieste, Bologna, Paris, Cologne, Paderborn, Würzburg, Ingolstadt, Eichstädt, Prague, Glatz, Neisse, Canada.—The eclipse of November 8, 1612, is also interesting. It was observed by Blessed Charles Spinola at Nangasacki; Fr. Julius de Alenis at Macao, Fr. Uremanns at the same place, Fr. Scheiner in Ingolstadt.

The transit of Venus of 1761 was observed* at Vienna by Fathers Hell, Liesganig, Steinkellner, Mastalier and Richtenburg, at Madrid by Fr. Rieger and others, at Florence by Fr. Ximenes, at Ingolstadt by Fr. Kratz, at Würzburg by Fr. Huberti and others, at Schwetzingen by Fr. Mayr, at Dillingen by Fr. Hauser, at Laibach by Fr. Schöttl, at Tyrnau by Fr. Weiss.

These current observations, however, are just the business of every observatory and of every astronomer.—I will therefore give prominence only to those observations which were either very excellent or the first to be instituted in any one direction, or otherwise very remarkable, and in their enumeration I will keep to the customary classification of the Sun, the Moon, and the Stars.

The Sun.

To begin with the Sun, the first place not only among Jesuit astronomers, but among all old astronomers, is due to Fr. Christopher Scheiner. I say the first place, because he was by all odds the first to occupy himself thoroughly for many years with the Sun; because he was the first to arrive at results which have value even today, and of which it is not at all certain that they have really been improved upon.

Fr. Christopher Scheiner (born in Suabia 1573, died in Neisse 1650) had already in presence of his pupil Cysatus discovered sun-spots in March, 1611, and from that time on had observed them uninterruptedly, and indeed in order to make sure of the matter, had organized a whole corps of solar observers, all Jesuits, to observe simultaneously with himself: Fr. J. B. Cysatus

* De Backer.—Title "Hell." [*Cfr. Astr. Papers of Amer. Ephem.* Vol. II.]

in Ingolstadt and afterwards also in other places, Fr. Chrysostom Gall in Lisbon, Fr. George Schönberger in Freiberg, Fr. Joseph Biancani in Parma, Fr. Caspar Ruess in the West Indies, Fr. Charles Malapertius in Belgium, and others. In the year 1631 he published his great work under the title Rosa Ursina, in which his observations are given and illustrated with very good drawings. The principal result of his researches is the determination of the elements of the Sun's rotation, that is, the inclination of the axis toward the ecliptic, the longitude of the ascending node and the time of rotation, performances which are indeed duly acknowledged in almost all astronomical text books. But the rest of the contents of the great folio volume is less known—and it is not less interesting. It is to be remarked that the telescope was invented in 1608 and that the tube with which Scheiner made his last observations, in about 1625, could not have been an excellent instrument, as well on account of lack of achromatism, as certainly also on account of want of proper polish and the smallness of the objective. At all events Scheiner is none the worse for his instrument, speaks often of its extraordinary performing power—because he happened to know nothing better. The principal reason of his seeing so much and such delicate things, that one is forced to wonder at it, must probably have been due to his skill, since he adopted various ways to protect himself against delusion and to insure the true facts of his observations.—Thus he was the first to apply the so-called dark glasses that are now used generally, and the first to invent the artifice of diaphragming the objective. In short, in the handling of the telescope he was perfectly at home, even the distortion caused by the objective did not escape him when he projected the Sun's image upon paper, which was his usual method of observing.

Now, Scheiner has established so many and such delicate facts with this telescope, that we can boldly maintain that, except for spectroscopy and photography, solar researches have not yielded anything new that is not already to be found in Scheiner's observations, as the astronomer Winecke declares* when he says: "In his Rosa Ursina truths are established that have been forgotten because the earlier observer was wantonly set aside, and the same had to be discovered anew not long ago." In order then briefly to indicate the most important things, the granulation was already known to him, no less than the veiled spots; although he does not use the word, which they did not yet

* Vierteljahresschrift d. Astr. Ges. 1878.

exist, his description of these phenomena is so clear and unmistakable that no doubt is possible about the matter. He has very thoroughly examined the formation and dissolution of the spots; and he treats in a masterly way the question which even today is much discussed, whether the spots are depressions. He proves himself possessed of a knowledge which was very advanced for that time, inasmuch as he establishes the proper motion of the spots in longitude and latitude, no less than the frequently eccentric position of the penumbra, and the more exuberant and solid development of the spots and faculæ at the Sun's preceding limb. The word faculæ comes from him. He had formed ideas about the physical constitution of the Sun very like those of today, and he even surmised the interior of the Sun, the nucleus or kernel, to have a rotational velocity different from that of the outer shell.*

The Moon.

The Moon was studied in a thorough manner by Fathers J. B. Riccioli and Fr. M. Grimaldi,—or as v. Littrow in his "Wunder des Himmels" expresses himself in a somewhat queer fashion, "the well known Jesuit Riccioli has occupied himself very much with the Moon and with the whole of astronomy generally, without, however, thereby advancing this science very much." We shall see later that this view is not shared by others. I have shown elsewhere† that v. Littrow's notice, which begins with the above words, and with which he makes fun of Riccioli's lunar nomenclature, is false in all its details and only proves that v. Littrow was very poorly informed in lunar affairs. Now, Riccioli has introduced the lunar nomenclature which is in use even today, and in a very systematic, but hitherto entirely overlooked manner, has very much lessened the labor of the memory in locating the lunar formations. But his colaborer Grimaldi drew up one of the first maps of the Moon worthy of the name. The first was the map of Langren of 1645, then the one of John Hevelius followed in 1647. In the year 1651 Fr. Riccioli published in his "Almagest" the map of the Moon that Grimaldi had designed and drawn from his own observations. Edmund Neison, the renowned lunar topographist of the present day, makes the

* [For further information the reader is referred to "P. Christoph Scheiner, S. J. und seine Sonnenbeobachtungen" by the same author, *Natur* und *Offenbarung*, Vol. 48.]

† Die Mondnomenklatur Riccioli's und die Grimaldische Mondkarte, Stimmen aus Maria-Laach. Freiburg i. Br. 1898, Pamphlet 3.

following remark about this map.* "Riccioli, although an inferior observer to Hevelius, has had the merits of his map much underestimated; for it appears to have been the result of good lunar observations, and is in some particulars superior in completeness and accuracy even to Hevelius's, though from his less exact estimates of distances it is less so on the whole. But his labors have afforded results far superior to what would have been expected from the disparaging observations of Beer and Mädler. In his remarks as to the probable nature of the surface Riccioli is juster than most of his immediate successors." Riccioli and Grimaldi have in addition occupied themselves much with observations of the libration, so that Riccioli himself says that Grimaldi's observations of the libration, when gathered together, would make a good-sized book. Both carried on a lively expistolary correspondence with Hevelius.

The Stars.

In the realm of the stars also the Jesuits have done some meritorious work.—To begin with the planets, it is to be noted that Fr. John B. Zupi was the first to discover the dark stripes or bands that are to be found on Jupiter. In regard to Saturn (already before Huygen's time) a determination of Grimaldi's† which gave Saturn the nearly correct oblateness of 1-12 was about the only certain result. The phases of Mercury, which Galileo surmised more than saw, were first seen by Fr. John B. Zupus in Naples on May 23, 1639, and repeatedly afterwards; he also furnished accurate drawings.

An epoch-making discovery in the domain of the fixed stars, which was at first misunderstood, but which continually found more recognition, is due to Fr. Christian Mayer, astronomer at the Mannheim observatory. Humboldt pronounces in a very acceptable way about it‡: "Christian Mayer, the Mannheim astronomer, has the great merit of having first (1778) made the fixed stars a special object of research, by the sure method of actual observations. The unfortunate choice of the term *satellites of the fixed stars*, * * * exposed him to bitter attacks from his contemporaries * * * That dark planetary bodies should become visible by reflected light, at such an immense distance, was certainly improbable. No value was set upon the results of his carefully conducted observations, because

* Neison, The Moon, London, 1876, p. 87.

† Wolf, Handbuch II, 470.

‡ Humboldt, Cosmos, Otté's translation, London 1851, vol. 3, p. 275.

his theory of the phenomena was rejected; and yet Christian Mayer, in his rejoinder to the attack of Father Maximilian Hell, Director of the Imperial Observatory at Vienna, expressly asserts "that the smaller stars, which are so near the larger, are either illuminated, naturally dark planets, or that both of these cosmical bodies—the principal star and its companion*—are self luminous Suns revolving round each other." The importance of Christian Mayer's labors has, long after his death, been thankfully and publicly acknowledged by Struve and Mädler. In his two treatises, *Vertheidigung neuer Beobachtungen von Fixsterntrabanten* (1778), and *Dissertatio de novis in Coelo sidereo Phaenomenis* (1779), eighty double stars are described as observed by him, of which sixty-seven are less than 32″ distant from each other. Most of these were first discovered by Christian Mayer himself, by means of the excellent eight-foot telescope of the Mannheim Mural Quadrant; "many even now constitute very difficult objects of observation."

The duplicity of many stars was, of course, known before, but no concern was shown as to whether they were optical or physical pairs; this was first rendered possible by measurements, of which Fr. Christian Mayer made the beginning, and which are even now or only just now being continued with great ardor. Amongst those who paid special attention to this duplicity, we again find some Jesuits, and their observations relate to the southern sky. Humboldt writes:† "* * * I there drew attention to the fact that α of the Southern Cross, * * * is one of those stars whose multiple nature was first recognized in 1681 and 1687 by the Jesuits Fontaney, Noël, and Richaud. * * * This early recognition of binary systems, long before that of ζ Ursæ Maj.‡ * * * is the more remarkable, as Lacaille, seventy years later, did not describe α Crucis as a double star * * * Richaud also discovered the binary character of α Centauri, almost simultaneously with that of α Crucis, and fully nineteen years before the voyage of Feuillée to whom Henderson erroneously attributed the discovery."

The Comets.

The comets also engaged the attention of the Jesuits. Fr. John B. Cysatus is worthy of especial mention in that he was

* The term companion or comes has since that time become standard.—Fr. J. S.

† Humboldt, Cosmos. vol. 3, p. 317, note.

‡ Probably not correct. For Riccioli noticed it already in 1650; perhaps it was noticed before, but I have no evidence.

the first to use a telescope on a comet. It was the comet of 1618. He has published a paper on it, *Mathemata Astronomica* * * * Ingolstadii, 1619, which according to Wolf* "is justly numbered among the most important papers of former times concerning comets." A remarkable passage that occurs in it, has hitherto been overlooked. Wolf says† that Kepler and his contemporary Cysatus in their writings which appeared on occasion of the comet of 1618, already speak of a definite orbit, an almost straight one, of the comet, whilst until then comets were allowed to roam about in a lawless manner. However, Cysatus did not unconditionally trust the straightness of the path. He says that the path from the beginning of December until nearly the 7th of January corresponded to a straight line, but after that less so. "This curvature (of the orbit) would be a phenomenon of great importance, if it could be confirmed by more observations. For I will not come to a decision from the case of this one comet. For it is possible that on account of inadvertance the stars are not accurately plotted on the globe or that the observation of the comet's position in the line of the two fixed stars‡ (although accurately made) is really not so infallible. I therefore leave the case undecided."—The orbit was really not straight but elliptical, and it redounds to the honor of Cysatus that this small deviation from a straight line did not escape him in his observations.

Moreover Fr. Cysatus was the first thoroughly to study the structure of the comet, inasmuch as he was the first to apply the telescope to this purpose. He distinguished the nucleus and the coma in the head of the comet. Both terms remained in scientific usage. He says he had employed much diligence and much time in the work, and had made use of two tubes, one six, and the other nearly ten feet long.

He furnishes a very presentable description, one, in short, like those to be read today in text books of astronomy. Thus, for example, he says expressly that 1. the nucleus was visible, 2. there was a nebulous envelope about the nucleus, and 3. that outside of this envelope there was yet a luminous appearance, but considerably fainter, that therefore there were two brighter rings about the kernel. This may be the first observation referring to it, as it is perceptible only with a telescope, and no one had used the telescope upon comets before him.

* Wolf, Gesch. d. Astr. p. 409.

† Wolf ibidem, p. 410.

‡ He observed the comet's position by alignment.

The extraordinary violent movements of the tail, and its retrograde lengthening and shortening (recounted by Littrow*), are also described in the observation of the 4th of December.

He always measured the diameter of the nucleus as well as of the coma. Once he saw in the coma a small star which he thought belonged to the nucleus; but in an hour and a half it developed into a fixed star by coming out of the coma.

Nebulae.

The same paper also contains the first account of the nebula of Orion, which he brings in as an explanation of the structure of the comet's head. "For the rest Bessel already spoke for the priority of Cysatus, and as his reclamation was little heeded I renewed the same," says Wolf.†—I add also that Cysatus was the first to mention not only the nebula of Orion, but even the so-called trapezium, that is, those stars that are compressed into a very narrow space in the nebula. This is a considerably more delicate discovery than that of the Orion nebula as a whole, and indeed only possible with the aid of a telescope, as Cysatus himself says: "for with the tube one sees, etc." This fact has hitherto remained entirely unknown. He says: "For the rest this appearance is like that of a crowding of stars near the last star in the sword of Orion; for with the tube one sees how in like manner some stars are compressed into a very narrow space, and how round about and between the stars a white light like that of a white cloud is poured out. This crowding of stars, I say, is very much like the head of the comet, only that it has somewhat more the form of a rectangle ("aliquanto oblongior")." It suffices to read this description, to contemplate the drawings of the head of the comet given in Cysatus's work, and to have seen the trapezium, in order to award the discovery of the trapezium at once to Fr. Cysatus.—The discovery of the trapezium is generally ascribed to Huygens, in as much as he declares it to consist of three close stars, to which he added a fourth in 1684; this may be corret, but that Cysatus has nevertheless seen the trapezium without determining the number of the stars, is beyond all doubt. He uses the expression "a few stars" instead of three or four; and as he declares this group of stars to be oblongior, he must have seen at least four stars; and this was as early as the year 1618.

* Wunder des Himmels, p. 565.

† Handbuch der Astr. I, 591.

Furthermore, another fact has been overlooked (probably not been read, because it was in Latin; all this being contained in the thirteen lines* in which he refers to the Orion nebula),—that Cysatus mentions also another nebula, which is without doubt the one of which Littrow says: "(AR = 277° 35′, = D — 24° 0′, in Sagittarius), a very fine spherical group, gradually brighter towards the centre, but without a true nucleus. The stars of the 11th to the 15th magnitude appear to be equally distributed throughout, and the boundary of the whole indistinct. Discovered 1655 by Abraham Ile," Cysatus says: "Finally, another nebulous ball, set throughout with small stars, and a little above the arrow of Sagittarius, is also like the head of our comet." As he writes this in 1619, the priority must without doubt be ascribed to him.

The "Nebulosa" appear in general not to have been strangers to Cysatus, as he repeatedly speaks of the stellæ nebulosæ, without adding anything that might show them to be new.

In speaking of comets we must also add the name of Fr. Nicolas Sarrabat, who was the first to discover the comet of 1729, which is marked as a telescopic one. Consequently he was the first to discover a comet with the telescope.

The observation of the zodiacal light, this celestial interrogation point so very mysterious even today, frequently engaged the labors of Fr. Francis Noël (1729, missionary in China) and Fr. Esprit Pezenas, professor of hydrography in Marseilles, later director of the observatory in Avignon, who, according to Wolf,† in 1730 discovered the so-called counterglow (Gegenschein) of the zodiacal light.

Maps of Countries.

It yet remains for me to speak of geodesy and geography, in as far as they pre-suppose astronomical observations. The performances of the old Jesuits in this respect, we may say it boldly, are of extraordinary value. Let us first cast a glance at China, that immeasurably great empire. "In ten years work, says Dr. Wegener,‡ the Jesuits had to sift the rich, extant, and partially newly-made material, and to set it right and complete it by means of a large number of astronomical re-determinations, which they executed in extended journeys throughout the whole

* Mathemata Astronomica, p. 75.

† Handbuch der Astr. II., 504.

‡ Dr. Wegener in the Zeitschrift der Gesellschaft für Erdkunde in Berlin. XXVIII. 202.

empire. The map, thus finished in the year 1718 and copies of it multiplied by means of a copper plate engraving, may unconditionally be put down as one of the greatest performances in the entire history of cartography. One must realize that an enormous area of eastern Asia was mapped upon it in more accurate detail than any one province of the small "Great Powers" of Europe at that time. The accuracy of the positions given upon the Jesuit map, at least in China proper, is so great, that modern deviations must always at first sight be considered with distrust. Thus, for example, the astronomical observations of the Széchényi expedition in the province Kansu proved the Jesuit positions to have been almost throughout more accurate than the deviations of Prshewalki."

Very much had already been done even before the definitive production of the map in 1718. "A decisive progress in the knowledge of China is connected with the appearance of the Jesuit Matteo Ricci, who obtained permission from the emperor in 1600 to make his permanent abode in Peking. Whatever views one may have concerning the political aims of that religious order, the history of the sciences can speak of the Fathers of Jesus only with wonder. Thus we are indebted amongst others to the Jesuit Martini, who returned from Asia to Europe in 1651, for the first atlas of China*, with which the newer knowledge of that empire begins. The Jesuits Grueber and Dorville reached Lhasa from Peking after a dangerous journey of six months, and from there descended to Agra over the Himalayas in 1661."† How many astronomical observations are contained in these few words and under what difficult circumstances!

To give only one example, Fr. Souciet, at the end of the first volume and as an appendix in the second volume, gives 218 positions, mostly from India, China, Thibet, amongst which are 111 from Fr. Gaubil, 89 from Fr. Noël. These are by no means all; but the enormous distances of the individual places sufficiently indicate what a value these determinations represent, as such long journeys through partially inhospitable regions and an unreliable population, journeys with the most primitive methods of conveyance, are by no means to be reckoned among pleasure trips. To these must be added many determinations of position in America, which probably brought many more difficulties along

* Novus Atlas Sinensis a Martino Martini S. J. appeared as the eleventh part of the Novus Atlas absolutissimus of Jansenius, 1655.—Martini was born in Trent.

† Peschel-Ruge, Geschichte der Erdkunde, Munich 1877.

with them and were ascertained mostly only with the gnomon, as it was impossible to drag more instruments along. In this connection a remark inserted by its writer in the article, "Fr. Marquette,* Discoverer of the Mississippi River," is interesting. "For some reason that I am not able to explain, the Jesuit missionaries generally made a mistake of about a degree in their latitude determinations. Every point upon their maps, which are otherwise executed with wonderful accuracy for their circumstances, lies so much more to the south than upon the present maps." There is question of North America in the cited essay. Perhaps this circumstance that the latitudes are all too small by "about a degree," and that this error is constant although the observers are different, may be explained in this way, that many missionaries, who were by no means provided with refined measuring instruments, determined their latitudes by means of the gnomon and took meridian altitudes. They overlooked the fact that the umbral shadow of the gnomon indicates only the altitude of the Sun's upper limb, so that the angle of elevation becomes too great, and the latitude therefore as much too small.—As in China and America, so also in other countries the missionaries did their best to make themselves useful to science. Thus Stöcklein† says of Fr. Neret: "He measured the latitude of every place he visited with the quadrant that he carried with him, and laid off the meridian with his magnetic needle." He occupied himself principally with Syria. And the same author says about Fr. Sicard that the measurements from Pelusium to Suez, Memphis, Cairo, Ramasse * * * and Tur to Sinai, he obtained from Fr. Claudius Sicard, "who not only visited all these places, but also very accurately measured them with the compass and quadrant, and moreover, in regard to measuring the length of terrestial arcs, drew the first meridian arc * * * through the city of Paris."

We might yet mention the maps of the various countries which the Jesuits penetrated as missionaries. Thus the Benedictine Knogler‡ writes to v. Zach: "I have * * * all respect * * * for the Macartney map; but in regard to the Chinese Wall I cannot consider it correct. This I have much more accurately and in greater detail on a map of Tartary (more correctly Mongolia)

* "Alte und neue Welt," 1876, p. 646. Note 2.

† Allerhand So Lehr—als Geistreiche Brief, Schriften u. Reis—Beschreibungen, welche von denen Missionariis der Gesellschaft Jesu * * * in Europa angelangt sind. Augspurg und Grätz, 1728.

‡ Monatl. Korrespondenz, 1800, March, p. 247.

executed by the Jesuits, which however is not engraved. On this the Wall looks very different. I can also send you a map of California drawn by the Jesuits." And v. Zach remarks hereupon: "Although the coasts of California have become more accurately known * * * since the observations of the latest circumnavigators, these older maps of the Jesuits may yet furnish a knowledge of the interior of the country which we do not up to the present possess, and therefore give a valuable contribution to the knowledge of countries." And Humboldt writes:* "Fr. Fritz had come to Quito with another German Jesuit, Fr: Richter; he drew up a map of the Amazon river in the year 1690, the best that could be had before La Condamine's journey." La Condamine himself, who travelled the same way, declares the map of the missionary Fritz to be "a valuable and unique piece, and one proving the ingenuity of its author." He there points out the enormous difficulties of the journey and the lack of instruments.

Equally remarkable and sensational was the map made by Fr. Francis Kino, born in Trent, apostle of Sonora in California, on which he drew the land route he had discovered to California in 1701, and thereby proved beyond doubt that California was a peninsula.

Fr. Adam Gilp (from Bohemia) designed a map of the province of Serres in the country of Sonora.

Fr. Liesganig superintended the construction of a large map of Galicia, consisting of 94 sheets, of which v. Zach says:† "The survey of Galicia was made under the direction of Liesganig (not without opposition on the part of some noble ignoramuses and surveyors) according to the well known and only true astronomical-trigonometrical method." At his side were the two Jesuits, George, baron of Mezburg and Francis Guessman. Mezburg later on conducted the survey of the west of Poland, that had been newly acquired, and began the map that Triesnecker completed. He also issued a postal map of the Austrian hereditary possessions. Fr. Christian Mayer did similar work. He published a "Charta geographica per tractum Rhenanum Moguntia Basileam usque."

The map of Carinthia by Fr. Charles Andrian, S. J., is also mentioned as a "beautiful and correct" one.‡

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* Humboldt's Travels to the Equinoctial Regions of America. Hauff's German Translation, vol. 5, p. 255. Stuttgart 1862.

† Monatl. Korresp. 1801 p. 554.

‡ Mitteil. des k. k. militärgeogr. Instituts. V. 1885 p. 152.

Fr. Claudius Dechalles is also worthy of remark. As professor of hydrography in Marseilles "he there drew up a large map of the Mediterranean Sea resting upon astronomical observations, which was never indeed engraved but far surpassed the contemporary very erroneous maps."

In cartography mention must also be made of Fr. Nicasius Grammatici (1684-1736), of whom v. Zach reports:* "Nic. Grammatici of the Society of Jesus is known to all astronomers by his writings. * * * He deserves to be placed among the number of those astronomers whom we * * * have specially cited as being the first in the construction of geographical maps to have regard to the oblateness of the Earth and to recommend it to others."

While he may not independently have designed maps of countries, Fr. Ignatius Weinhart, professor of mathematics in Innsbruck, yet has rendered great service in this direction, as the famous "Bauernkarte" [Peasants' map] is, so to speak, due almost entirely to him.† For he had taught the Peasant Peter Anich surveying and the manufacture of suitable instruments, as well as making the necessary astronomical observations. Later on, after Anich had developed into a thorough geometer, Fr. Weinhart was authorized by the government to superintend Anich's survey of the Tyrol. In 1766 came the order "to take the Original-Mappam, as it had been designed by the late Peter Anich * * * and to copy it most accurately under the supervision of Professor Fr. Weinhart." For superintending and supervising the whole enterprise, Fr. Weinhart repeatedly received the highest acknowledgments and a medal of honor bearing the effigies of the empress and her consort.

Measurements of Terrestrial Arcs.

It yet remains to say a word about the measurements of terrestrial arcs. While the efforts of learned men at the end of the 17th century were being directed towards determining the size, and later on also the shape, of the Earth, the Jesuits also from that time on took a modest part in this by no means easy affair. Fr. Riccioli and Fr. Grimaldi in 1645 were the first to attempt the measurement of a degree of the meridian by means of mutual terrestrial zenith distances. It probably came out too large. For "this measurement of terrestrial zenith distances would be

* Monatliche Korrespondenz, Vol. I, p. 241. Note.

† Mitteilungen des k. k. militargeographischen Institutes. V. 1885, p. 106 seq.

the simplest and best means of measuring the Earth if refraction did not exist or at least if it were more amenable to computation than has hitherto been the case."*

Upon this followed in the year 1702 the measurement of the arc which Fr. Anthony Thoma undertook in China and near Peking.† For it was in December 1702 that the emperor Kang-Hi ordered Fr. Thoma to measure a degree upon a large plain near Peking in company and with the co-operation of his third-born Prince, and in the presence of many mandarins of the Mathematical Tribunal. The presence of the imperial prince, who was himself a lover and connaisseur of mathematics, in which the Jesuits had educated him, and of the mandarins who were so very inimical to the European mathematicians, admits of our conjecturing with good reason that Fr. Thoma would not be wanting in diligence and in the exactitude of his measurements. The result is given in Chinese and also in old-Roman scale.

It is only the difficulty of reducing the unknown Chinese foot. and in like manner the old Roman foot, to the French scale that is in the way of our arriving at an exact knowledge of the result. Knogler,‡ who occupied himself with the case, took the mean of the lengths of the old Roman foot given by various writers in comparison with the French, and thus obtained a result that was only nearly 24 toises in excess of the one computed (in 1800) with the latest value of the ellipticity. However this is always very uncertain. There is a remarkable passage in Baron Richthofen in regard to this. He says that the Jesuits in China always endeavored to introduce a scale of measurement that was definite and easily comparable to the French, and that for the reason of being able to make their measurements more accurate, they concluded to put 200 Li equal to an equatorial degree. Kang-Hi established this as the official standard, and even at present it serves as the norm most frequently used for computation. The length of such a Li is 556.5 metres. Now 200 such Li are equal to 111,300m. But according to Jordan an equatorial degree is equal to 111,306.6m. No second arc measurement was undertaken in China, and as the establishment of this standard comes from the emperor Kang-Hi, there can be no doubt that the 200 Li = 111,300m. mentioned by Richthofen are deduced from this base measurement and seem to come very near to the truth.

* Handbuch der Vermessungskunde of Dr. W. Jordan. Stuttgart 1878. Vol. 2, p. 4.

† Monatl. Korrespondenz of v. Zach. 1800. March and June.

‡ Monatl. Korresp. Ibidem.

For only two assumptions are possible: either at the computation of this equatorial degree the view of the French Academy at that time, which considered the Earth as a perfect sphere, was adopted, and then the value of the degree is about 140 toises too great, or Newton's oblateness (1/229) was used, and the truth was approached more closely. That the second assumption is the more probable appears from the expression "*equatorial* degree," which has no real meaning in the first assumption.

Upon this followed in 1775 the arc measurement of Fr. Boscovich and Fr. Maire and yielded a result which, according to Wolf,* "does all honor to the two geodetes, if we consider the instrumental means at their disposal." The occasion† of this measurement was "the want of agreement of the arc measurements of Peru, France and Lapland, which had led Boscovich to the idea that the Earth was perhaps not an ellipsoid of revolution * * * and that in order to answer this question it would be useful to measure another degree in the same latitude with the French one but in a different longitude. With the means then at hand, however, the measurements thereupon undertaken by him could impossibly lead to a decisive result * * *; on the other hand the train of thought of Boscovich, and especially the method, according to which he somewhat later on deduced the most probable value of the ellipticity (1/273) from the results of all the measurements accessible to him, represented for geodesy the dawn of a new day."

In regard to this arc measurement Wolf says:‡ "The sole important advance at that time was that at his arc measurement in the States of the Church Boscovich departed from the customary application of contact measurements * * * he then did not in practice bring the rods to a complete contact, but determined by means of a dividers and plotting scale the distance of the contiguous points."

It appears from the publications of the royal imperial military geographical institute¶ that Fr. Liesganig began the astronomical geodetic survey in Austria-Hungary in 1762. He undertook the measurement of a meridian arc at the command of the empress Maria Theresa. The apparatus constructed by Liesganig for the measurement of the base of the newer part of Vienna

* Wolf, Handbuch d. Astr. II, p. 193.
† Ibidem.
‡ Handbuch d. Astr. II. p. 15.
¶ 1884 p. 176 seq.

served for such measurements until 1810. Gunther* remarks upon this: "Liesganig's work does not enjoy a particularly good reputation on account of its result, but it is not to be denied that its plan completely corresponds with the scientifico-technical norms that were considered the standards at that time; especially the considerations concerning the differences in the length of a Steyermarkian and of a Croatian degree, which are said to be conditioned by the attraction of the mountains, give no unfavorable testimony to the criticism of the learned Jesuit. His computations therefore must have been injuriously influenced by some constant errors of a particular kind."

Finally Fr. Christian Mayer measured a degree in the Palatinate, as he says in a certain publication.†

Published Works.

In conclusion yet a word about the literary activity of the Jesuits. Amongst the many works I call attention only to those that were considered important at their time and enjoyed praise or acknowledgment among the learned. I omit the various publications of the observations.

Amongst the astronomical writers the oldest of them must be named first. This is Clavius. Christopher Clavius, called the Euclid of his century, was born in Bamberg in 1538. At the age of 17 he entered the Society of Jesus, in which he distinguished himself in mathematics. Pope Gregory XIII made use of his knowledge for the reform of the calendar, which he had repeatedly to defend against many attacks. He died in Rome in 1612. Amongst his 26 works, of partly mathematical, partly astronomical contents, many of which passed through various editions and that in folio. I call attention to the following and add the judgment of Houzeau:‡

Commentarius in sphaeram Joannis a S. Bosco.—"This treatise is the best commentary ever written on the astronomy of Sacrobosco."

Gnomonica libri 8 * * * 1581.—"This is the greatest work on gnomonics that exists, a work that may be considered an encyclopedia of skiatherics."

Rom. Calendarii a Gregorio XIII. restituti explicatio 1603.

* Günther, Lehrbuch der Geophysik u. phys. Astronomie. Stuttgart 1884, Vol. 1, p. 144. Note.

† Basis Palatina * * * exeunte aune 1762 ad normam Academiae regiae Parisinae scientiarum exactam bis dimensa * * * a Chr. Mayer, S. J.

‡ Houzeau Vademecum de l' Astronomie, p. 110.

"Gives the completest idea of the elements of the Gregorian reform."

Next there are some noteworthy works on Chinese astronomy. To these belong Fr. Gaubil's Traité de l'Astronomie chinoise, "an important work."* Then Liber organicus by Fr. Verbiest, but especially his "Astronomia europea sub imperatore * * * Cam Hi * * * in lucem revocata * * * Dilingæ 1687." "This book is necessary for those who wish to learn the astronomy of the Chinese."† These are the most important among the many works on astronomy in China. We might also mention the various star tables, edited with Chinese text by the Jesuits, especially the planispheres, which were published after a work of Fr. Pardies and contain star positions projected upon the faces of a cube circumscribing a sphere. Fr. Pardies had invented this method of projection.

J. B. Riccioli (Ferrara 1598, Bologna 1671) published various works on astronomy, but the most important is his Almagestum novum * * * Bononiæ 1653. Fol. and Astronomia reformata * * * Bononiæ 1655. Let us first listen to the weighty judgment of v. Littrow on Riccioli: "The well known Jesuit Riccioli has occupied himself very much with the Moon and with the whole of astronomy generally, without however thereby advancing this science very much."‡ Very flattering! J. C. Houzeau in his Vademecum de l' Astronomie (p. 116) entertains a somewhat different view when he writes: "Riccioli Almagestum novum. This immense work, a treasure of astronomical learning, forms a veritable encyclopedia of the science of the stars." And "Astronomiæ reformatæ tomi 2. The collection of observations, which forms the tenth and last book, is a valuable source." An old savant had called the Almagestum novum the pandects of astronomical knowledge.¶ It seems therefore that v. Littrow has accidentally overlooked these two works or not known of their existence.‖ The object of this colossal work is given by Riccioli

* Houzeau, p. 44.

† Houzeau p. 44.

‡ Die Wunder des Himmels, 7th edition, p. 401.

¶ Morhof Polyhistor, t. II, vol. II, p. 347.

‖ [Compare Newcomb's vindication of Hell against the misrepresentations of Littrow in the Astronomical Papers of the American Ephemeris, vol. II, pp. 301, 302: "The conclusion was reached that Littrow's inferences were entirely at fault * * * Littrow's mistakes were due to the fact that he was *color-blind to red*, in consequence of which he wholly misjudged the case on first examining the manuscript, and afterward saw everything from the point of view of a prosecuting attorney."—Transl.]

himself in the preface with sufficient explanation. He intends to offer "an astronomical work, which may be a kind of library for the men of our Society and for others who cannot have access to the great number of such books or the leisure to read them, a work, in which I have collected with the greatest clearness the whole of the old and the new astronomy, together with the controversies that occur therein." The work becomes yet more valuable on account of a personal index, used perhaps for the first time, in which nearly all the persons mentioned in the book are recounted and accompanied by the data of their lives. The work also contains a number of accurately stated observations made by himself as well as by others.

Maximilian Hell, a Hungarian, born 1720, died 1792. When Maria Theresa in the year 1756 erected the observatory at the Vienna university, Hell was called to be its director on account of his attainments, and remained in this position during 35 years until the end of his life. A call to England with a considerable salary, which he received at the time of the Suppression of the Society, he declined. Amongst the many works that he published the ephemerides deserve particular mention. This was the first undertaking of its kind after the Connaissance des temps, the first therefore in German countries.

The ephemerides appeared each year and always contained appendices, that is, treatises on various astronomical subjects. The first were published from 1757 until 1792; from that time on Fr. Francis Triesnecker undertook their continuance until the year 1806. Triesnecker himself wrote astronomical works and treatises; but perhaps it redounds more to his praise that he "was an unselfish astronomical computer,"* who at once used the many observations of occultations reported to him for the determination of positions (in longitude).

Roger Boscovich (Ragusa 1711, Milan 1787) might also be mentioned. Amongst the nearly 70 publications of this genial man, of partly mathematical, partly astronomical contents, there are many very excellent ones, as for example, the one on gravitation; again, about comets "de orbitis cometarum determinandis 1774;" and "De annuis fixarum aberrationibus," in which he gives formulæ for the change of position caused by parallax and refraction. All these works Houzeau mentions in an especial manner.

May these few works among the many suffice to show that the

* Wolf, Handbuch d Astr. II, p. 311.

old Jesuits have produced something worthy of mention in astronomical literature.

With this I deem my task accomplished, in that I have briefly shown the intimate relationship of the old Jesuits to astronomy, principally by recounting their observatories, by giving their performances in respect to astronomical instruments, their more remarkable observations, some priorities especially, their application of astronomy to cartography and arc measurements, and finally by mentioning some of their numerous astronomical writings. I believe the activity of the Society of Jesus in this field will not be undervalued, but it will be acknowledged that she has done much for her circumstances. To present this truth in its proper light, was also the purpose of these lines.

THE SUN'S MOTION REFERRED TO A GROUP OF FAINT STARS.

GEORGE C. COMSTOCK.*

A year ago I presented to this Society a set of proper motions of faint stars (ninth to twelfth magnitude, distributed throughout the twenty-four hours of right ascension) determined from micrometric observations extending over a period of about half a century. During the past year I have derived from these proper motions a determination of the direction and magnitude of the Sun's motion using Airy's method for the formation of the necessary equations. This method requires that some assumption shall be made with regard to the distance of each star employed and for this purpose I have used an extrapolation of Kapteyn's formula which represents this distance as a function of the proper motion and stellar magnitude.

I have thus derived from absolutely new data, no one of the proper motions employed having entered into any previous investigation, the following co-ordinates of the apex of the solar motion:

$$\text{R. A.} = 297^\circ \qquad \text{Decl.} = +\ 28^\circ$$

The mean result of previous determinations from brighter stars is R. A. = 275°, Decl. = + 30°. My solution furnishes as the linear velocity of the Sun's motion 4.8 radii of the Earth's orbit per annum, which compared with Campbell's spectroscopic result, 4.2 radii per annum, indicates that the assumed parallaxes

* Read at the meeting of the Astronomical and Astro-Physical Society of America, St. Louis, Dec. 30, 1903.

of the stars are not greatly in error. Adjusting the assumed distances so that the resulting solar velocity shall agree with the spectroscopic determination I find for the average parallax of 67 stars included between the ninth and twelfth magnitudes, $\pi = 0''.0051$.

This number, 67 stars, represents the entire amount of data at my disposal, no proper motion having been rejected in the discussion, but it is, doubtless, too small a basis for a determination of the elements of the solar motion and at least provisionally, I prefer to interpret the results noted above as evidence that the proper motions obtained for these faint stars are real quantities and that the methods employed for their derivation may with advantage receive wider application. I have now in hand a similar determination of proper motions of all stars fainter than the eighth magnitude for which suitable data can be obtained from the earlier double star observations of the Struves.

WASHBURN OBSERVATORY, Dec. 24, 1903.

SEEN AND LEARNED ABROAD.

T. D. SIMONTON.

FOR POPULAR ASTRONOMY.

A trip abroad is a rest, a diversion to a business man—it may also be an education; and especially may it be this to the man of science, or to the lover of science, with the latter of whom I claim my place. To both these seekers after increased knowledge must the variety and the expansion incident to a European journey and residence be a God-send of opportunity. The writer has never ceased to appreciate his experience of a year and a half so spent, but now so many years ago, 1887-1888, that he should never have thought of recounting incidents thereof for publication, save at the earnest solicitation of the editor of this journal, who was complimentary enough to say that not alone what was strictly new, but even what many of us may have read about, might come with interest from the hand of one with whom it was a matter of personal experience. In response he shall endeavor to select such matter—largely from a personal journal kept at the time—as may not be inappropriate to a place in these pages.

When out for days beyond the sight of land we realize the fitness of the expression "the great deep," and that regarded from the outside—as possible observers upon Mars may scan our

planet—we must appear in a general way a remarkably smooth and uniform spheroid (most likely *sphere*, unless their instruments surpass ours), details of which are provokingly hard to make out, since we are always immersed in the sunbeams when nearest to them. However, our permanent ice caps at either pole may be a consolation to them and a starting point in seeing likeness in us to themselves. We are led to a new and more vital appreciation of what our astronomers and mathematicians have done for us, when we see the ship's officer day by day, by a simple observation or two of the Sun, turn into his room with the utmost confidence that he has secured the position of the ship upon the great ball of water presenting the side of a world.

In a word permit me to say our journey, that of my wife and myself, included England, Scotland, Wales, Ireland, and the continent as far as Rome, with a residence of weeks, and even months, in such centers as London, Edinburgh, Berlin and Rome.

As we decided upon our lodgings in Edinburgh I noticed a door plate on the front of the next house, "Challenger Expedition." Simply by accident we were planted for weeks next door to the headquarters of that great expedition of research upon the sea that after three years' absence had returned with its treasures of fact and material from the great deep, and where the collating and editing of the matter of the expedition was going on. Of the 32 great volumes finally issued, 23 were completed. Sir Wyville Thompson had been editor-in-chief, but his death had caused the work to fall into the hands of (now Sir) John Murray. This I had already learned, as also many other facts that prepared me for matters of science abroad from my reading of "Nature" for years. Within a day or two I was favored with an introduction to Mr. Murray. He turned from his desk, and finding in me an American who knew something of the great Expedition, his interest and kindness could not have been surpassed. He explained how the work of editing was planned and effected—how the treasures of research in the museum in another room, which I was permitted to inspect, even handle in some instances, were placed in expert hands in the kingdom, on the continent, and in America, so that whether it were matter for the chemist, the geologist, the naturalist, the biologist or the ichthyologist the best results might be obtained from their assiduous studies and reports. It was indeed a privilege to look over the treasures of their research and their dredgings in all seas, in some instances of fish or shell or strange creature the sole example in the possession of man was there to be seen. I asked about a heavy piece of

stone lying on the floor. "Oh, that is a piece of the Antarctic Continent." Before leaving the room Mr. Murray had said to me, "These two volumes, The Narrative of our Expedition, are at your service while you remain in Edinburgh; take them to your lodgings next door;" On a subsequent visit I had considerable conversation with him on his favorite themes of oceanic research and Antarctic exploration. Before leaving he gave me 3 specimens in vials of deep* dredgings specially arranged for microscopic examination. "Globigerina ooze, depth 1450 fathoms, Diatom ooze, 1950 fathoms;" and lastly (to show detail of record on all the vials) in full, "Radiolarian ooze with Globigerina, No. 271, Date Sept. 6th, 1875, Lat. 0° 33′ 0″, Long. 151° 34′ W., Depth 2425 fathoms"—nearly three miles.

July 25, 1887. "Went to see Mr. Buchan the meteorologist at his office, 122 George St. He is completing the meteorological work—the reductions, tabulation and results—for the Challenger Publications. He showed me his sheets in progress. Introduced me to his assistant and said they both expect to be at the Meeting of the British Association at Manchester. He encouraged me to try to be present—which I now begin to think I may. Mr. Buchan is an enthusiastic meteorologist, and has charge of the Ben Novis Meteorological Observatory, noted for its elevated position and also for its equipment. He showed me the first specimen of stellar photography I have seen, the work of Mr. Roberts living near Liverpool. I was delighted with the plate, and can conceive that here is a great aid to certain kinds of astronomical research."

July 18. "Had an invitation from Mr. Murray to the Meeting of the Royal Society of Scotland, to which I went at 8 P. M. Some ten members sat around a table. A gracious, large mouthed, fine looking gentleman, Sheriff Irvine, of Drum, was in the chair. A score or two persons were there on invitation also, like myself.

Several papers were presented and on subjects abstruse enough; yet the business was so managed that it was in no sense tedious. Not one of the papers was read in full. The introduction perhaps was given, and then a summary of the points presented. The rest was left to be looked up when the paper should appear in print. Several of the papers (from different authors) were presented by the same large, slightly bald, broad faced gentleman, and it seemed to me, with admirable clearness and comprehensiveness. I had been introduced to a member, Lord McLaren,

* If any of the readers are enthusiastic in microscopic research I could spare samples of all these vials for their gratification. The supply was generous.

one of the judges presiding over the courts in Edinburgh, and asking him who it was that was able to present so admirably those varied papers, he replied, 'That is Professor Tait.' Mr. Buchan, the meteorologist and Mr. Murray each presented a paper also in good style. The whole meeting was over and we had our cup of tea in the rear room before 10 P. M.

At the Museum of Arts, Sciences and Antiquities, amid a world of interesting objects, I was especially attracted by an immense stalagmite from a cave in Java. It is in size, shape and appearance so much like a large saw-log that I had to read the description of it to be sure it was not a petrified tree trunk. It must be more than 30 inches in diameter and about 20 feet long. Was brought over a hundred years ago from Java, through the scientific curiosity and liberality of a naval officer. A short stump was left where it was sawed off. The cave was again visited by the recent Challenger Expedition and the stump examined and noted to be covered with some nodules of matter deposited from the dripping water. The cubic contents of these nodules were carefully measured, and taking into account their volume, the time taken for their formation, and a like rate of deposition accorded to the original stalagmite, when sawed off it must have been 600,000 years old!

In the Botanical Gardens and Arboretum of Edinburgh we found a place of some 70 acres, a treat to the eye and the lungs. The "Rock Gardens" consisted of mounds and walks set off with any kind of rough stones for ferns and all kinds of hardy plants. Alpine plants and various species of sempervivum were numerous."

If it were not too discursive I might tell how with the co-operation of botanist, the landscape gardener, the architect and artist, what was once a great rough ravine in the very heart of Edinburgh, has been transformed into the charming Princes Street Gardens, one of the leading attractions of the city, with its bright public buildings and statues to honored citizens gleaming amid a profusion of grass, plants and flowers. For the engineer I might refer to the great North British R. R. bridge under which we passed, then being thrown across the Firth of Forth with its main spans of 1700 ft. and its workmen on its high towers (360 ft. aloft) dwindled to pigmies. I might tell of the Caledonial canal cleaving Scotland diagonally from southwest to northeast by utilizing the waters of certain lochs, so that we could reach Inverness on Moray Firth of the North Sea, passing through the midst of the highlands and having Ben Novis

(4406 ft.) a prominent land-mark half the way. If I had space to describe possibly I might interest the geologist in a personal visit to Fingals Cave, which at a little distance seems to be a door-way into a steep island resting on myriads of hexagonal iron (really basalt) columns, some of which having been undermined by the sea, have fallen, making the opening of the cave, into which we were permitted to go by boat from our steamer. Or I might refer to the Giants Causeway in Ireland as consisting of similar columns projecting up from the shore and out of the water of the sea, and broken off at varying heights. The student of forestry would be interested in the approach to the seat of the Duke of Argyle, through the finest display of planted forest trees we have ever seen. The pines were simply magnificent. A record says, "this forest was planted by the great Marquis of Argyle, leader of the Covenanters, and finally executed in Edinburgh in 1661." It requires some effort to believe this, so natural does the wild and bestrewn forest look now.

At Port Rush, after a splendid coach ride clear round the northeast end of Ireland, we hoped to have a ride upon the first electric road ever built—to be driven by the water power of the Falls turned into electricity. It was a measurable success for a time, with its "third rail" at one side a foot or two above ground. Though at that time disused to our great disappointment, as a first move toward what has since been accomplished in electric traction it was an honor to him by whom it was invented and installed—Sir William Siemens—to whom also we are under great obligation for the construction of the first Atlantic cable. A memorial window in Westminster Abbey is a fitting recognition of the services of this eminent man of science.

STATISTICAL COMPARISON OF THE MINOR PLANETS AND THE SHORT PERIOD COMETS.

M. O. CALLANDREAU.*

The great number of small planets give us today very favorable conditions for statistical research, as Monsieur de Freycinet and Monsieur Jean Mascart pointed out a short time ago.

It is well known that in the average of numerous results the individual anomalies disappear and general laws are made manifest.

* Translated by Miss Isabella Watson.

To avoid too frequent corrections we may limit ourselves today to the consideration of the whole number of planets discovered in the 19th century, a number scarcely less than 500.*

In the following table the distribution of the elements is indicated: eccentricity, inclination, semi-major axis and perihelion distance when the aphelion distance, equal to $a\,(1 + e)$ in ordinary notation, is taken as an argument, as it is natural to do for a comparison with cometary orbits. The second column: *Number*, indicates the numbers of the aphelion distances included within the respective limits.

Limits of Aphelion Distance.	Number.	Means of Eccentricities.	Means of Inclinations.	Means of Semi-major Axes.	Means of Perihelion Distances.
			°		
.....	....	.....	.....	.....	.....
2,35–2,44.....	5	0,075	3,7	2,24	2,07
2,45–2,54.....	19	0,099	5,7	2,29	2,06
2,55–2,64.....	16	0,100	5,4	2,35	2,12
2,65–2,74.....	23	0,122	5,9	2,41	2,12
2,75–2,84.....	34	0,141	8,0	2,46	2,13
2,85–2,94.....	43	0,122	7,3	2,60	2,29
2,95–3,04.....	40	0,131	7,2	2,65	2,32
3,05–3,14.....	41	0,127	7,9	2,75	2,41
3,15–3,24.....	43	0,144	9,9	2,80	2,40
3,25–3,34.....	45	0,155	9,5	2,86	2,43
3,35–8,44.....	40	0,161	10,7	2,94	2,48
3,45–3,54.....	36	0,174	8,5	2,99	2,48
3,55–3,64.....	24	0,188	10,7	3,03	2,46
3,65–3,74.....	19	0,194	8,5	3,09	2,49
3,75–3,84.....	18	0,201	11,7	3,17	2,54
3,85–3,94.....	7	0,212	6,3	3,21	2,54
.....	....	.....	.....	.....	.....

We have not considered the results for which the averages depend on less than five numbers.

According to the table the aphelion distances scatter themselves symmetrically around their mean just as the accidental errors do. The mean, as M. Jean Mascart has noticed, is found near to the distance corresponding to the great gap, for which the average movement of the small planets is about double that of Jupiter.

The eccentricities increase quite regularly; yet there seems to be a slight discontinuance for the average aphelion distance, the numbers increasing noticeably when you pass from the upper to the lower part of the table.

The inclinations give occasion for similar remarks, except that

* The tables for the history and statistics of the minor planets, published in 1901 by Dr. J. Bauschinger include, it is true, the history of the planets discovered in the 19th century. But I have used the Annuaire du Bureau des Longitudes in my statistic abstracts begun some years ago; the last planet is numbered 470.

a progressive increase is not shown in the second series of numbers.

For the perihelion distances we notice that the numbers at the beginning and those of the second half taken separately, are almost identical; also that the difference of the two groups is small in comparison with the increase of the aphelion distance.

In the following table is shown, taking as an argument the longitude of the aphelion, the distribution of the elements: e, i, a, $a(1+e)$; the second column: *Number* shows the number of elements included between the respective limits.

Limits of Longitude of Aphelion.	Number.	Means of			
		Eccentricities.	Inclinations.	Semi-major Axes.	Aphelion Distances.
			°		
0– 20°	16	0,100	8,2	2,80	3,14
20– 40	12	0,142	7,8	2,72	3,12
40– 60	19	0,124	10,5	2,77	3,12
60– 80	19	0,144	9,0	2,79	3,19
80–100	25	0,120	8,4	2,69	3,01
100–120	16	0,161	10,6	2,76	3,21
120–140	28	0,175	8,8	2,78	3,26
140–160	43	0,150	7,2	2,71	3,11
160–180	37	0,180	3,5	2,77	3,26
180–200	47	0,148	9,2	2,76	3,16
200–220	34	0,162	9,4	2,80	3,26
220–240	42	0,150	8,2	2,78	3,20
240–260	31	0,152	7,4	2,81	3,23
260–280	28	0,137	9,0	2,86	3,26
280–300	17	0,145	8,5	2,87	3,27
300–320	25	0,129	7,6	2,71	3,06
320–340	13	0,154	10,2	2,75	3,18
340–360	15	0,110	8,8	2,80	3,11

It seems according to the numbers, and the thing is still more evident in a graphical representation, that the distribution is nearly symmetrical with relation to the longitude intermediate between 180° and 200°, that is, near to that of the aphelion of Jupiter: the aphelia of the small planets tend to go in the direction of that of Jupiter; there are 306 on the one side, 161 on the other.*

But we notice besides the constancy of i and especially of a for the different values of the longitude.

My object has been to establish a comparison of the asteroids and the short period comets, whose number at present is 31; these, being situated at the outer limit, as it were, of the ring of asteroids, seem to differ from them only by their physical aspect.

* This fact has been noted for a long time. Newcomb explained it in 1862, in No. 1382 of the *Astronomische Nachrichten*, by the secular perturbations of Jupiter. M. Doberck published in 1879 tables extending to 191 planets. The theory agrees with observation.

The recent discoveries have made known cometary orbits but little different from the circle, with large perihelion distances. The Holmes comet might have been considered an asteroid during the stellar period. On the other hand there are asteroids, like (345) Tercidina, not to mention Eros, subject to variations in brilliancy; others that could never be found again, perhaps because their existence was ephemeral like that of the comets. Kirkwood discussed in 1888 the question of the origin of short period comets. The difficulties of the capture theory, which explains by the disturbances of the large planets the changing of the parabolic orbits of comets into contracted elliptical orbits, seemed to him so great as to make him prefer the theory which sees in these comets asteroids which have undergone more than others the disturbances of Jupiter; the variations in brilliancy could come from a physical action accompanying the disturbances and more marked when the bodies approach each other. Although the number of comets of short period is still moderate, a statistical comparison is not without interest for solving the problem.

The elements of the tables given below were taken from a list published by M. Fayet (*Bulletin astronomique*, 1899), completed with the *Connaissance des Temps* for 1905.

Limits of Aphelion Distances.	Number.	Means of			
		Eccentricities.	Inclinations. °	Semi-major Axes.	Perihelion Distances.
4,00–4,49.....	....	.....	....	.....	.....
4,50–4,99.....	6	0,56	16	3,13	1,40
5,00–5,49.....	7	0,59	8	3,31	1,38
5,50–5,99.....	10	0,66	18	3,45	1,20
6,00–6,49.....	5	0,71	11	3,64	1,05
6,50–6,99.....	....	.....	....	.....	.....

Limits of Longitudes of Aphelion.	Number.	Means of			
		Semi-major Axes.	Inclinations. °	Aphelion Distances.	Perihelion Distances.
....	..	.....	....	.....	.....
40–100.....	4	3,21	12	5,22	1,19
100–160.....	5	3,37	10	5,40	1,34
160–220.....	9	3,57	14	5,83	1,32
220–280.....	8	3,41	14	5,54	1,29
280–340.....	4	3,17	15	5,60	0,72
....	..	.....	....	.....	.....

The results not considered depend on only one number. We find for the short period comets the analogue of the distribution for the small planets; the aphelion distances are scattered about a distance little different from the aphelion distance of Jupiter, the eccentricity seems to increase with the aphelion distance while

the inclination shows no tendency to increase. It is clear that bodies having a considerable aphelion distance escape observation the less easily because the eccentricity of the orbit is greater. Note the decrease of the perihelion distances contrary to what was found in case of the asteroids.

The second table, where the longitude of the aphelion is taken as the argument, shows clearly the symmetry with relation to the aphelion of Jupiter and the exaggeration of the numbers of aphelia in agreement with that of the planet (22 to 9, taking into account a number not inscribed in the table). The inclination is almost constant, but the semi-major axis and the aphelion distance remarkably constant, especially the first, for the small planets, seem to depend here on the aphelion of Jupiter. The corresponding perihelion distance is greater while we find it a little less for the asteroids.

The comparison of the aphelia with the nodes of the asteroid orbits shows a characteristic difference. Taking the whole number of asteroids for which the inclination is more than the average 8° we distinguish no grouping. For the 25 orbits of inclination greater than 20°, 18 to 7 aphelia are in the hemicycle which surrounds the node. But there is nothing striking as in the case of the short period comets, where the rule is that the aphelion is near to the point of closest approach to the orbit of Jupiter; just where the action ought especially to be produced and at a relatively recent date for each comet, since, contrary to the asteroids, there is but a slight dispersion of the aphelia to the one side or the other of the plane of the orbit of Jupiter.*

Now let us come to the effect of the disturbances of Jupiter on the form of the orbit.

Taking the simple case of an orbit within that of Jupiter, in the same plane, and utilizing certain remarks of M. Schulhof (*Bull. astr.*, 1898, p. 338), it is at once easy to show that the perihelion distance q of an orbit comparable with that of an asteroid, diminishes when the eccentricity e increases.

In fact, we deduce from the known relation between a and e,

$$\frac{1}{2a} + \frac{\sqrt{a\,(1-e^2)}}{a'^{\frac{3}{2}}} = \text{const.}$$

* It would have been better to refer all the orbits to the plane of the orbit of Jupiter, as M. Jean Mascart did for the 417 first small planets (*Bulletin astronomique*, 1899); the conclusions would probably not have been appreciably different.

(a' radius of the orbit of Jupiter), the differential relation

$$\left((1+e)\,q^2-(1-e)\,a'^{\frac{3}{2}}\sqrt{q\,(1+e)}\right)dq$$
$$+\left(q^2-a'^{\frac{3}{2}}\sqrt{q\,(1+e)}\right)qde = 0;$$

the coefficient of dq is < 0, as also that of qde, if

$$\left(\frac{q}{a}\right)^3 < \frac{(1-e)^2}{1+e}.$$

For different values of e the superior limits of q are given below:

Values of e.....	0,40	0,50	0,60	0,70
Limits of q.....	3,3	2,9	2,4	2,0

M. Schulhof mentions as an example the comet 1867 II, whose orbit is subject to great variations of eccentricity in a rather short period of time. At the same time that q is decreasing, which tends to bring the object within the sight of the observer, the orbit is lengthening, and the comet, in case of a meeting with Jupiter, remains for a long time in the neighborhood of the planet and undergoes great disturbances.

But there is reason for considering other things besides the mechanical action.

It is natural to admit that Jupiter, which shows so much affinity with the Sun, exercises on the materials of the planets passing in his vicinity a physical action similar to that of the Sun; that the comets then experience some changes in their internal structure, accompanied by an increase of their brilliancy more or less permanent. This explains the fact proved by M. Schulhof that many periodical comets have been discovered soon after their passage in the vicinity of Jupiter. It should be noted that, if the intrinsic influence of the planet is small, it exercises itself during a much longer time than that of the Sun; it acts especially at the aphelion, and that explains in turn that the corresponding perihelion distances are the greater, as one of the above tables shows.

To sum up:

At the inferior limit of the ring of the asteroids, for the small aphelion distances, we have small eccentricities and inclinations. The eccentricities increase with the aphelion distance, without its being the same with the inclinations. The perihelion distances scarcely increase at all. The orbits seem to be capable of division into at least two groups. The action of Jupiter becomes manifest in the distribution of the orbits.

Farther away, at the outer limit of the zone, the short period comets show a special distribution. The great variation of the eccentricity in short intervals, followed by a diminution of the perihelion distance and an appulse toward the orbit of Jupiter, the double action of the planet, mechanical and physical, explain the apparition of new comets; feebly constituted, they are not long in dissolving, thus leaving a provision of matter available for other formations.

The ideas given above about the origin of cometary materials do not essentially differ from those that M. Radau set forth in his remarkable account in the *Annuaire du Bureau des Longitudes* for 1903. They have been more or less explicitly pointed out by many astronomers beginning with Lambert who says in his *Lettres cosmologiques*: "The comets lose at each return toward the Sun a little part of their atmosphere * * * This matter may remain in storage, so to speak, until the comet during its revolution comes there to make its new provision of atmosphere, when it goes away from the Sun." (Translation of Darquier, p. 115.)

It will be noted besides that the theory of Kirkwood, which I have tried to state precisely, returns thus into that of capture, relieved of the arbitrary hypothesis of a primitive parabolic orbit.

It seems premature just now to wish to decide between the different theories. But if it were possible, by means of the present power of the spectrographs, to make a detailed analysis of the light of short period comets, these physical data would usefully complete the direct observations. Mr. Barnard has insisted not long since (*Astron. Journal*, No. 246) on the characteristic difference of aspect of the comets of short duration and the comets properly so called. Is there perhaps some difference in their spectra? Then we shall see whether or not the two classes of bodies form parts of the same family.

CURIOUS OPTICAL ILLUSIONS.

ARTHUR K. BARTLETT.

FOR POPULAR ASTRONOMY.

Among the various phenomena of nature that occur unpredicted and unannounced to mankind, there are few more interesting to scientific students, and probably none so deceptive and commonly misunderstood by the general public, as the luminous

colored circles occasionally seen around the Sun, and more frequently around the Moon, known respectively as the solar and lunar halo. These remarkable exhibitions of nature, owing to the complicated appearances they sometimes present, have long engaged the attention of meteorologists, and were, until within a comparatively recent time, extremely difficult to explain. Though more frequently observed in the polar regions, there are probably few persons of mature age, residing in the temperate latitudes, who have not, at some period of their lives, witnessed one or more exhibitions of these curious and beautiful phenomena, which perhaps more than any other manifestations of nature, have engaged the observation of the unscientific world, and attracted multitudes of thinking people to the study of physical science, particularly that fascinating department pertaining to the atmosphere.

There are probably no displays of nature, either in the heavens or the Earth, about which the people are so misinformed, and regarding which so many erroneous notions seem to prevail, as the occurrence of solar and lunar halos, together with the anomalous appearances usually presented by them, though the amount of ignorance relative to these wonderful exhibitions is not surprising when we consider their puzzling nature, and the deceptive features that invariably accompany them, which at one time the wisest philosophers were unable to correctly interpret and explain.

Whenever, under favorable conditions, we observe a luminous circle of the various prismatic colors around the Moon, the sky within the circle being much darker apparently than it is upon the outside, (which is the peculiar feature of a lunar halo) an observer is very naturally led to believe that a ring of light does actually surround the Moon's disk, while inside the ring there is but little, if any, light at all, the sky being dark and unilluminated, and that portion just outside really much brighter, though less bright than the ring itself. Now, it is in this belief that we are deceived by appearances, and that the perplexing nature of a halo is well illustrated; and yet, people will claim, as "seeing is believing," they have an ocular demonstration that a real luminous circle does surround the Moon, and that the dark sky inside receives no light from the Moon's disk, being actually without any illumination, as it appears to be. But paradoxical as it may seem, it is nevertheless a fact, that the sky is really no brighter where the circle of light appears than it is anywhere else around the Moon, and only seems to be for the reason that owing

to the refraction of the Moon's light at an equal distance from her disk, on all sides, more of the luminous rays reach our eyes from the portion of the sky where the circle or ring is seen.

That there is no real luminous circle around the Moon, and that the sky is equally bright where it appears the darkest—the whole appearance being deceptive, as above stated—will be manifest when the cause and nature of the singular phenomenon are fully understood. The late Professor Proctor, explaining similar phenomena in a very interesting and instructive newspaper article entitled "Seeing is Deceiving," well remarked: " 'Seeing is believing,' says the old proverb, but 'seeing is deceiving' would be nearer the mark. We are deceived almost as often, perhaps quite as often as not, by what we see. We are deceived by false impressions even when we know the real state of the case, so that nature may in some sense be compared with a conjurer who explains the trick he is about to play, yet deceives the eye as perfectly as though we knew nothing about the manner of his performance. We know that that handkerchief which we gave him to experiment upon has not been cut in half, yet we saw him cut it in half; we know he has not pounded our gold watch with a mortar, yet that is what we saw him do."

The lunar halo, which by many persons is regarded as a remarkable and unexplained luminosity associated with the Moon, is to meteorological students neither a mysterious nor an anomalous occurrence. It has been frequently observed, and for many years thoroughly understood, and at the present time admits of an easy scientific explanation. It is an atmospheric exhibition due to the refraction and dispersion of the Moon's light through very minute ice-crystals floating at great elevations above the Earth, and is explained by the science of meteorology, to which it properly belongs; for it is not of cosmical origin, and in no way pertains to astronomy, as most persons suppose, except as it depends upon the Moon, whose light, passing through the atmosphere, produces the luminous halo, which, as will be seen, is simply an optical illusion originating, not in the vicinity of the Moon—two hundred and forty thousand miles away—but just above the Earth's surface, and within the aqueous envelope that surrounds it on all sides.

A lunar halo, or circles of prismatic colors seen around the Moon, never occurs except when the sky is somewhat hazy, and presents a dull leaden appearance. Usually only one circle is seen surrounding the Moon, and it is always of large size, being about forty-five degrees in diameter, or eighty times the apparent diam-

eter of the Moon, corresponding to one-half the distance from the zenith to the horizon. The sky within the circle is always apparently much darker than it is for some distance on the outside —a feature which is the peculiar characteristic of a halo when seen under the most favorable conditions—and the circle exhibits the seven prismatic colors seen in the rainbow, the inner edge being red and quite sharply defined, while the other colors are more or less mingled and superposed, so that the outer edge of the circle is nearly white and usually not very clearly defined.

Sometimes a number of large circles are seen around the Moon, presenting a peculiar and very complicated appearance, and they are seldom concentric as in a lunar corona, but intersect each other with mathematical exactness, exhibiting a structure that is often wonderful to behold. A true halo is never produced when the sky is perfectly clear, as a slight haze is essential to its appearance, and the beautiful illusion is visible only under rare and peculiar atmospheric conditions. In connection with a halo, white bands, crosses or arches, are sometimes observed, which also result from the same conditions of the atmosphere at great elevations above the Earth.

A halo may form around the Sun as well as around the Moon, and all the curious features above described are similarly observed; but a halo is most frequently noticed about the Moon for the reason that we are too much dazzled by the Sun's light to distinguish faint colors surrounding its disk, and to see them it is necessary to look through smoked glass or view the Sun by reflection from the surface of still water, by which means its brilliancy is very much reduced. When a halo is seen around the Sun, a white circle passing through the Sun and parallel to the horizon is sometimes observed, which is known to meteorologists as the "parhelic circle," from the fact that parhelia or mock-suns are frequently noticed in connection with it. These productions which are commonly called "sun-dogs," are faint images of that luminary, appearing at one, two or more points in connection with a halo, and at those parts where the circles cross each other, or cut the parhelic circle above mentioned. The number of these mock-suns or parhelia, visible at the same time, is variable; sometimes one or two only are to be seen, at other times four or five, and on some occasions as many as seven have been observed at once. These mock-suns usually appear about the size of the real Sun, but not quite so bright, though on rare occasions they are said to rival their parent luminary in brilliancy and splendor.

Such appearances, which are also seen about the Moon,

(known as mock-moons or "moon-dogs") are most frequently observed in the polar regions, but often occur in the more temperate latitudes, and are produced by the extra light concentrating at those points where the circles intersect, there being at such places a double cause of illumination, presenting the singular spectacle of a faint white disk, resembling that of the Sun or Moon. Parhelia, or mock-suns, are generally red on the side toward the Sun, and they sometimes have a prolongation in the form of a tail, several degrees in length, which coincides in direction with that of the parhelic or horizontal circle. A recent writer on the subject says: "Parhelia have been observed frequently both in ancient and modern times. Aristotle records two appearances of these meteors, and Pliny mentions their occurrence at Rome. A double parhelion, which was noticed before the Christian era, is referred to by St. Augustine. Many others have been observed from different points on the continent. On the 2nd of January, 1586, Christopher Rotham saw, at Cassel, before sun-rise, an upright column of light of the breadth of the Sun's disk. As he rose to view, he was preceded and followed by a parhelion, which appeared in contact with his orb, and continued visible for thirty minutes, and then were hidden by a cloud. On the 28th of February, 1551, mock-suns were seen at Antwerp; and on the 17th of March of the same year, a similar phenomenon, with two halos, was witnessed at the same place. Four days after the last named, two parhelia, with three halos were seen at Madgeberg."

A halo may be produced artificially, and its appearance beautifully illustrated, by crystallizing some salt (such as alum) upon a glass plate, and then looking through the plate at the Sun or a bright light, when the luminous circles above described will be observed. The formation of a circle of light around the Sun or Moon, and the production of the dark circle to which we have referred, may also be illustrated by an interesting imaginary experiment, which is thus described by the late Professor Loomis, an eminent authority on the subject of atmospheric phenomena: "If we conceive a beam of light to be admitted through a small aperture into a dark room, and to fall upon a large number of ice-prisms having angles of sixty degrees, and occupying every possible position, all the incident rays will be deviated from their first direction, but in no case will the deviation be less than about twenty-two degrees. A large number of spectra will be cast upon the opposite wall, but opposite to the aperture through which the light is admitted, there will be a circle of twenty-two degrees

radius upon which no spectrum can fall, and the red end of each spectrum will be turned toward the center of the circle. If the number of the spectra be sufficiently great, they will together form a circle of twenty-two degrees radius, bordered with the red upon the inside; but beyond the red the different colors will be so superposed as to produce a light nearly white. * * * The circle within the halo is much darker than the space without it, because from no part of this circle can a ray of the Sun, refracted by the ice-prisms, reach the eye of the observer."

The halo is less brilliant and beautiful, but far more frequent, than the rainbow. Scarcely a week passes during the whole year in which the exhibition does not occur. In summer the ice-crystals that produce the halo are three or four miles high, above the limit of perpetual frost, and for this reason the apparition is sometimes called the "frost-bow." As the rainbow is sometimes seen in dew-drops on the ground, so the "frost-bow," just after sunrise, has been noticed in the crystals which fringe the grass. A halo is the bright border of an illuminated zone, and Professor Olmsted says: "As in the rainbow, so in the halo, the visible band of colors is only the border of a large illuminated space on the sky. The ordinary halo, therefore, is the bright inner border of a zone, which is more than twenty degrees wide. The whole zone, except the inner edge, is too faint to be generally noticed, though it is perceptibly more luminous than the space between the halo and the luminary."

A corona is an appearance of faintly-colored rings, often seen around the Sun and Moon when a light, fleecy cloud passes over them, and should not be mistaken for a halo, which is much larger and more complicated in its structure, as explained above. These two phenomena are frequently confounded by inexperienced observers, but they exhibit peculiar features by which each may be easily distinguished from the other. Both exhibit the seven prismatic colors, but in a corona the colors are reversed, the red being on the outer edge instead of on the inner edge, as in a halo; and the circles of a corona, besides being smaller, are concentric with each other—the inner one being small, the diameter of the second being double, and that of the third treble, the diameter of the first. The structure of the corona is quite simple, and never exhibits the attractive features observed in the halo, which is a production of comparatively rare occurrence, while a corona may be seen every time a light, transparent cloud comes between us and the Sun or Moon, and is produced by the diffraction of light passing between the minute globules of condensed vapor in a

cloud.

What we have said regarding the size of a halo, will alone enable an observer to recognize this phenomenon and distinguish it from a corona. Professor Loomis says: "The mean of eighty-three measurements of the radius of the red circle of a halo is 21 degrees 36 minutes, which is almost identical with the radius computed from theory." The diameter of the luminous circles of a corona is not always the same, and while they are never large, the diameter of the first red ring varies from three degrees to six degrees, and that of the second red ring from five degrees to ten degrees.

A corona, like a halo, may be easily produced artificially. If we sprinkle upon a pane of glass a small quantity of lycopodium, or any very fine dust of nearly uniform fineness, and then look at the Moon through this glass, we shall see it surrounded by luminous rings of prismatic colors, precisely like those that are formed by a cloud; and if on a cold winter evening, we breathe upon a pane of glass, the breath will condense into very small globules and freeze. If we look at the Moon, or even at a street lamp, through this glass, we shall see a similar system of colored rings, having violet on the inside.

More solar and lunar halos are usually seen in winter than in summer, owing to the favorable conditions of the former season for the formation of ice-crystals in the upper regions of the atmosphere, upon the existence of which such illusions depend for their production, and the singular appearances they present. During the cold weather that prevailed in the winter of 1887-8, the frosty condition of the atmosphere was particularly favorable for the production of these curious displays, and many exhibitions of the kind were observed in various portions of the country where such appearances are uncommon, and have seldom, if ever, occurred before. Many reports of such luminous circles appeared in the newspapers at that time, some of the exhibitions having been unusually interesting and remarkable, but none of the accounts seen by the writer—with one or two exceptions—explained the phenomena correctly, or mentioned their real nature, which was evidently not known or misunderstood by those who described them. On the evening of March 30th, 1890, a beautiful lunar halo, accompanied by a "moon-dog," was observed by the writer, and on the following morning a brilliant solar halo, with two "sun-dogs," appeared about one hour after sunrise, which attracted great attention from those who were fortunate enough to witness the interesting exhibition.

In January, 1888, a leading metropolitan newspaper published the following account, which illustrates the deceptive nature of such appearances, and the erroneous ideas regarding them: "Yesterday, shortly before noon, the Sun shone through a heavy bank of dull clouds. On each side were two lesser luminaries, scarcely less bright than the Sun, and about the same altitude as it. Well up toward the zenith appeared two rainbows, joined like two C's placed back to back. These were not brilliant, but were clear and distinct. High above these rose two more rainbows, placed in a like manner, the colors mingling in the most harmonious blending at the junction. These two were brilliant, and the ends of each bow were as even as if cut off with a knife. At the right of the upper bow was another equally brilliant bow standing alone. This lasted several minutes, and was seen by a great number of people." Now, the "two lesser luminaries" mentioned by the writer of the above, were really not "luminaries" at all, but simply parhelia or mock-suns, the nature of which we have already explained; and the "two rainbows" were doubtless portions of an incomplete circle, or the curious arches to which we have referred, the whole representation constituting a typical solar halo, which is exceedingly rare in this portion of the country. The reference to a "rainbow" in connection with the exhibition described, is certainly amusing, and it is perhaps unnecessary to state that a rainbow, though exhibiting the prismatic colors seen in a halo, is never observed in the immediate vicinity of the Sun, but always in the opposite part of the heavens, and is never produced except when rain is actually falling from the clouds.

Of all the numerous weather proverbs current among the people, those relating to the production of a halo should be included with the few for which there is considerable scientific foundation, justified by actual experience and observation. There is perhaps no better known, or more popular weather prognostic than that pertaining to the lunar halo, which has long been recognized, even among scientific persons, as an almost unfaillng sign of foul weather, and reliable indication of an approaching storm. One of the old familiar proverbs relating to the lunar halo is expressed in the lines:

"When round the Moon there is a brugh
The weather will be cold and rough."

Professor John Westwood Oliver, in a recent article on "The Moon and the Weather," published in Longman's magazine, says: "The halo is an old sign of bad weather. Of sixty-one lunar

halos observed in the neighborhood of London, thirty-four were followed by rain within twenty-four hours, nineteen by rain within four days, and only eight by no rain at all." As a halo is never seen except when the sky is hazy, it indicates that moisture is accumulating in the atmosphere, which will form clouds, and usually result in a storm. But the popular notion that the number of bright stars visible within the circle indicates the number of days before the storm will occur, is without any foundation whatever, and the belief is almost too absurd to be refuted. In whatever part of the sky a lunar halo is seen, one or more bright stars are always sure to be noticed inside the luminous ring, and the number visible depends entirely upon the position of the Moon. Moreover, when the sky within the circle is examined with even a small telescope, hundreds of stars are visible where only one, or perhaps two or three, were perceived by the naked eye.

A lunar halo, when seen under favorable conditions, with all the curious features that usually accompany it, is one of the most interesting and beautiful exhibitions of nature; and there are many remarkable facts connected with its formation and appearance that can not be dealt with in a popular description of the phenomenon, but which are fully explained in nearly every work on natural philosophy, meteorology or physical geography. In Professor Loomis' "Treatise on Meteorology" may be found a clear and exhaustive description of halos and coronas, fully illustrated and scientifically explained. There is an instructive popular article entitled "The Lunar Halo," by the late Professor Proctor, in his admirable work "Flowers of the Sky," which contains an excellent engraving illustrating the one-ring halo, most commonly observed, and showing the dark space around the Moon, which is always noticed in a perfect halo, and is thoroughly explained in the above mentioned work, together with many other paradoxical features and curious illusions, associated with the wonderful atmospheric spectacle.

BATTLE CREEK, Mich.

MEASURES OF THE RINGS OF SATURN.

F. E. SEAGRAVE.

FOR POPULAR ASTRONOMY.

The enclosed measures of Saturn's rings were made here from August 18th to November 9th, 1903. The planet was examined on about forty nights from the middle of June to

the middle of November. There were only ten nights out of the forty that were called good, and only three (3) where the seeing was excellent. These measures were made to still further test Struve's theory that the Saturnian Ring system has undergone since the epoch of its discovery great and surprising changes. M. Struve claimed after making a series of measures at Pulkova in the years 1850 and 1851, and comparing them with those of other astronomers taken on previous occasions, that the outer diameter of the Ring System remained constant while the inner diameter was gradually decreasing at the rate of about 1″.25 per century. A decrease large enough to bring the inner edge of the inner bright ring into contact with the ball about the year 2155. The investigations of M. Struve depended largely upon

MEASURES OF COMBINED WIDTH OF RINGS A, B AND CASSINI DIVISION.

Preceding Side.

75° Merid. 1903	Time. h m	Microm. Rev.	Sets.	Result. ″	Seeing.
Aug. 18	8 45	0.627	3	7.281	Good.
Sept. 6	8 15	0.587	3	6.937	"
8	9 00	0.590	4	6 989	"
12	8 00	0.595	4	7.082	"
26	8 30	0.591	3	7.175	Excellent.
Oct. 19	6 0	0.547	3	6.894	Good.
22	5 30	0.548	3	6.941	Excellent.
31	5 40	0.540	2	6 944	"
Nov. 3	5 15	0.538	3	9.952	Good.
9	5 00	0.530	2	6.916	"
		Mean		7.011	

Following Side.

1903	h m				
Aug. 18	9 15	0.597	3	6.935	Good.
Sept. 6	8 45	0.582	3	6.878	"
8	9 30	0.589	4	6.977	"
12	8 30	0.581	4	6.917	"
26	9 00	0.578	3	7.018	Excellent
Oct. 19	6 30	0.542	3	6.832	Good.
22	6 00	0.540	3	6.841	Excellent.
31	6 10	0.535	2	6.880	"
Nov. 3	5 45	0.534	3	6.901	Good.
9	5 30	0.534	2	6.968	"
		Mean		6.915	

the observations and measures of the astronomers of from 200 to 250 years ago, and made with very inferior telescopes. In the years 1881 and 1882 M. Struve made a further set of measures to test this, when the planet was situated in nearly the same part of its orbit. These measures did not verify the annual approach of 0″.012. The approach from 1851 to 1882 or for a period of thirty-one years was only 0″.04 instead of 0″.4. The results of my measures taken here on ten nights from August

18th to November 9 show that the combined width of the two bright rings and the Cassini division on the preceding side is 7″.011, and on the following side 6″.915. The distance from the inner edge of the inner bright ring to the limb of the ball on the preceding side measures 3″.661, and on the following side measures 3″.837. The ratio here of the space to the ring on the preceding side is 0.522, and on the following side is 0.554. Comparing these results with those of standard observers taken during the past 75 or 80 years show *no* constant decrease in the ratio (space to ring), and it seems to me as I stated nearly a year ago that Struve's theory should be abandoned on this account. Below are the ratios of the space to the ring from the results of different observers within the past 75 or 80 years.

DISTANCE FROM INNER EDGE OF RING B TO LIMB OF BALL.

Preceding Side.

75° Merid. 1903	Time. h m	Microm. Rev.	Sets.	Result. ″	Seeing.
Aug. 18	9 45	0.296	3	3.466	Good.
Sept. 6	9 15	0.304	3	3.628	"
8	10 00	0.311	4	3.719	"
12	9 00	0.317	4	3.791	"
26	9 30	0.308	3	3.758	Excellent.
Oct. 19	7 00	0.288	3	3.649	Good.
22	6 30	0.284	3	3.617	Excellent.
31	6 40	0.288	2	3.722	"
Nov. 3	6 15	0.279	3	3.625	Good.
9	6 0	0.277	2	3.634	"
			Mean	3.661	

Following Side.

1903	h m				
Aug. 18	10 15	0.305	3	3.562	Good.
Sept. 6	9 35	0.324	3	3.847	"
8	10 30	0.318	4	3.785	"
12	9 30	0.327	4	3.910	"
26	10 00	0.320	3	3.903	Excellent.
Oct. 19	7 30	0.305	3	3.862	Good.
22	7 00	0.305	3	3.881	Excellent.
31	7 10	0.309	2	3.991	"
Nov. 3	6 45	0.293	3	3.805	Good.
9	6 30	0.292	2	3.828	"
			Mean	3.837	

Ratio of space to ring { Preceding side 0.5222 / Following side 0.5549

The measures were made with an 8¼-inch telescope and power 312.

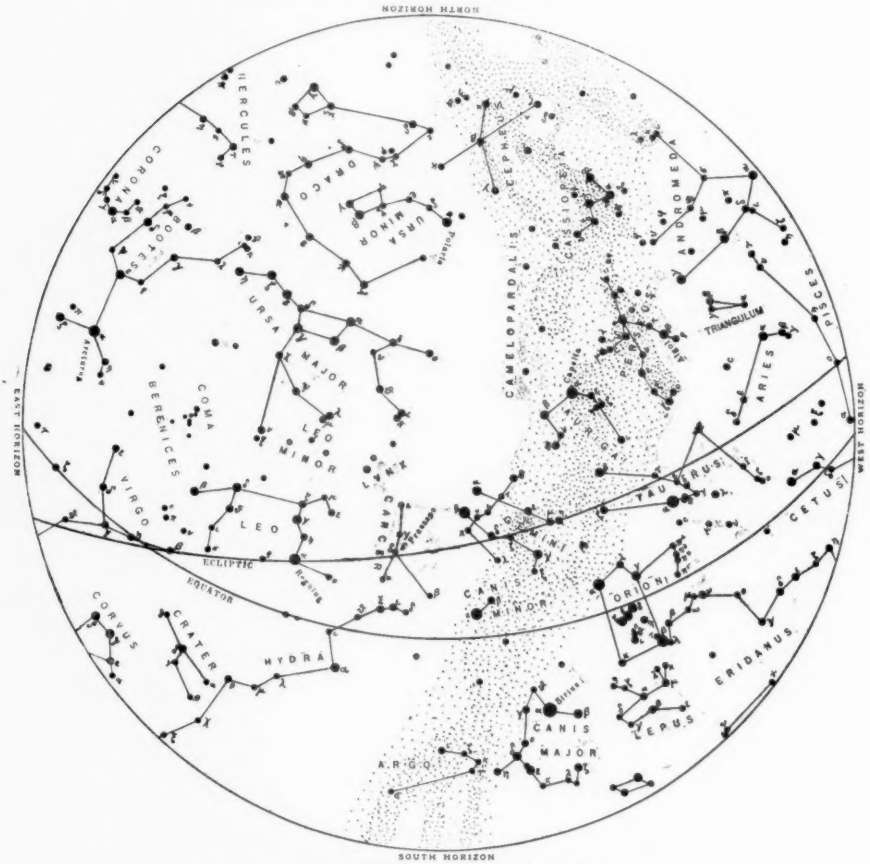
		Space / Ring			Space / Ring
1826	W. Struve	0.65	1880	Meyer	0.62
1837	Encke	0.67	1882	O. Struve	0.48
1838	Galle	0.65	1885	Hall	0.55
1851	O. Struve	0.49	1894	Barnard	0.53
1855	Secchi	0.53	1895	Dyson	0.46
1856	Jacob	0.60	1901	See	0.56

The white spots discovered on the ball by Professor Barnard, and observed by him and other astronomers during the past summer were *not* seen here at any time, even with the best seeing; and using all powers from 150 to 525.

PLANET NOTES FOR MARCH.

H. C. WILSON.

Mercury during March will be invisible to the eye, being on the farther side of the Sun. Superior conjunction will occur March 26.



THE CONSTELLATIONS AT 9 P. M. MARCH 1, 1904.

Venus is morning star, seen as the most brilliant star in the southeastern sky an hour before sunrise. It is only one-third as bright now as in the early part of this winter. The phase of Venus is now gibbous, approaching the full phase.

Mars has caught up with Jupiter in his eastward movement and during March will advance about 20° to the eastward of the latter along the ecliptic. Both planets will during this month be well behind the Sun, although they will be visible shortly after sunset during the first days.

Jupiter comes to conjunction with the Sun March 27 at 4 A. M., central standard time, thirteen hours after Mercury and the two planets will be in conjunction with each other on Mar. 26 at 8 P. M.

Saturn has come out from behind the Sun far enough to be in conjunction with Venus March 7 at 9 P. M. The two planets cannot be seen from America at that time but on the preceding and following mornings they will be seen quite near together.

Uranus will be at quadrature, 90° west from the Sun March 20, and so may be observed in the morning. The planet is to be found with the aid of a telescope among the faint stars between Sagittarius and Scorpio as shown on our chart in the January number.

Neptune will be at quadrature, 90° east from the Sun, March 23 at 11^h P. M It will be at the stationary point (west end of the loop) of its apparent path March 14. Its motion during the month will be very slow, the position being about midway between the bright stars η and μ Geminorum and 11′ south of the line joining those stars.

The Moon.

1904	Phases.	Rises. (Central Standard Time at Northfield Local Time 13m less.) h m	Sets. h m
Mar. 1-2	Full Moon	5 50 P. M.	7 02 A. M.
8	Last Quarter	12 51 A. M.	10 57 P. M.
16	New Moon	6 07 "	6 02 "
24-25	First Quarter	10 54 "	1 59 A. M.
30-31	Full Moon	5 54 P. M.	6 05 "

Occultations Visible at Washington.

Date. 1904.	Star's Name.	Magnitude.	IMMERSION. Washington M.T. h m	IMMERSION. Angle f'm N pt. °	EMERSION. Washington M. T. h m	EMERSION. Angle f'm N pt. °	Duration. h m
Mar. 6	η Libræ	5.5	13 06	86	14 14	311	1 08
7	24 Scorpii	5.2	15 08	78	16 24	309	1 16
9	B.A.C. 6287	6.0	17 11	75	18 39	286	1 28
10	ρ^1 Sagittarii	3.9	17 33	76	19 01	276	1 28
22	B.A.C. 1406	7.5	7 00	154	7 28	196	0 28
22	α Tauri	1.0	8 00	106	9 06	249	1 06
24	20 Geminorum	6.3	9 40	34	10 10	343	0 30
24	21 Geminorum	6.5	9 42	31	10 9	346	0 27
26	29 Cancri	5.9	8 21	119	9 39	275	1 18
27	o Leonis	3.8	15 21	94	16 10	300	0 49

Annular Eclipse of the Sun.—On March 16 from 14^h 36^m to 20^h 45^m Greenwich Mean Time there will occur an annular eclipse of the Sun, visible as a partial eclipse in the eastern part of Africa, the Indian Ocean, the southern part of Asia, Japan and the islands between Japan and Australia. A diagram showing the regions covered by the eclipse was given in our last number.

COMET AND ASTEROID NOTES.

Ephemeris of Encke's Comet.—Mr. F. E. Seagrave sends us an ephemeris of Encke's Periodic comet computed by himself from the following elements. These have not been corrected for perturbations and so may be considerably in error on that account.

ELEMENTS.

Epoch and osculation July 8.0, 1901 Berlin M. T.

$M = 339°\ 16'\ 15''.38$	$\mu = 1073''.875$
$\pi = 158\ 47\ 57\ .37$	$\log a = 0.3460351$
$\Omega = 334\ 48\ 58\ .06$	$\log q = 9.5335591$
$i = 12\ 53\ 38\ .46$	$\log \text{Aph} = 0.6122665$
$\phi = 57\ 46\ 44\ .82$	$P = 1206^d\ 20^h\ 13^m\ 55^s.2$

This comet is due to reach perihelion Jan. 4th, 1905. It should be visible towards the latter part of next September. The eccentricity of the orbit is considerable. So much so that the comet will describe a heliocentric arc of 234° in a period of only 116 days, or from Oct. 4th, 1904 to Jan. 28th, 1905. It will however take it 1090.8 days to describe the remaining 126°. The length of the orbit is about double its breadth. The periodic time has decreased 5 days 22½ hours since the year 1789.

EPHEMERIS OF ENCKE'S COMET.

Greenwich Midnight. 1904	α h	m	s	δ °	′	″	log r	log Δ
Oct. 4	1	27	18	+31	57	39	0.230488	9.879192
8	1	15	41	32	40	13	0.217646	9.843552
12	1	1	39	33	16	12	0.204121	9.807584
16	0	44	59	33	41	54	0.189848	9.771744
20	0	25	31	33	52	32	0.174749	9.736626
24	0	3	17	33	42	26	0.158738	9.702975
28	23	38	34	33	5	33	0.141712	9.671671
Nov. 1	23	11	52	31	56	39	0.123552	9.643658
5	22	44	0	30	12	44	0.104119	9.619824
9	22	15	51	27	54	17	0.083246	9.600824
13	21	48	12	25	5	14	0.060735	9.586951
17	21	21	32	21	51	45	0.036349	9.578144
21	20	56	3	18	20	23	0.009797	9.574098
25	20	31	41	14	36	38	9.980731	9.574448
29	20	8	8	10	44	8	9.948720	9.578978
Dec. 3	19	45	4	6	44	48	9.913241	9.587793
7	19	22	8	+ 2	39	27	9.873672	9.601484
11	18	59	9	− 1	31	6	9.829299	9.621208
15	18	36	18	5	44	36	9.779417	9.648623
19	18	14	20	9	56	11	9.723657	9.685527
23	17	54	45	13	58	37	9.662926	9.733189
27	17	39	56	17	43	40	9.601753	9.791418
31	17	32	44	21	3	13	9.552224	9.857408
1905 Jan. 4	17	35	14	23	48	38	9.533615	9.925048
8	17	46	43	25	52	16	9.556166	9.986970
12	18	3	42	27	13	26	9.607696	0.039121
16	18	22	43	27	59	11	9.669216	0.081759
20	18	41	45	−28	18	46	9.729561	0.116852

Nearest Earth Nov. 21, 1904. In perihelion Jan. 4, 1905.

F. E. SEAGRAVE.

Ephemeris of Winnecke's Comet.—In *A. N.* 3916 Mr. C. Hillebrand continues his ephemeris of Winnecke's comet to April 1. In all this time however the comet is on the farther side of the Sun and so near the line joining Earth and Sun that the only possibility of observing it will be in the bright twilight just before sunrise. There is very little hope of its being detected.

EPHEMERIS OF WINNECKE'S COMET.

Berlin M. T. 1904.	α App. h m s	δ App. ° ′ ″	log. *r.*	log Δ.
Feb. 1	20 14 47.17	−20 46 57.1	9.972633	0.276601
3	24 49.57	20 38 55.9		
5	34 45.89	20 28 49.3	9.978474	0.280344
7	44 35.45	20 16 41.5		
9	54 17.77	20 2 38.9	9.985794	0.284645
11	21 3 52.26	19 46 47.2		
13	13 18.57	19 29 13.3	9.994414	0.289439
15	22 36.23	19 10 3.8		
17	31 45.02	18 49 25.7	0.004129	0.294662
19	40 44.62	18 27 25.9		
21	49 34.89	18 4 11.3	0.014739	0.300253
23	21 58 15.57	17 39 49.1		
25	22 6 46.71	17 14 25.9	0.026059	0.306155
27	15 8.24	16 48 8.4		
29	23 20.23	16 21 2.8	0.037913	0.312312
Mar. 2	31 22.67	15 53 15.7		
4	39 15.70	15 24 52.5	0.050148	0.318669
6	46 59.37	14 55 59.0		
8	54 33.89	14 26 40.6	0.062629	0.325168
10	23 1 59.41	13 57 2.8		
12	9 16.11	13 27 9.8	0.075244	0.331755
14	16 24.18	12 57 6.7		
16	23 23.75	12 26 57.1	0.087896	0.338374
18	30 15.02	11 56 45.6		
20	36 58.19	11 26 35.4	0.100509	0.344983
22	43 33.48	10 56 30.4		
24	50 1.11	10 26 33.2	0.113024	0.351541
26	56 21.23	9 56 46.7		
28	0 2 34.25	0 27 13.4	0.125392	0.358013
30	8 40.19	8 57 55.6		
Apr. 1	0 14 39.33	− 8 28 54.1	0.137572	0.364369

New Elements of Planet (470) Kilia.—In *A. N.* 3917 Mr. H. Kreutz gives the following elements of this asteroid, depending upon four observations in 1901 and five in 1902:

Epoch	1901 April .90	1902 Oct. 21.0 Berlin
M =	350° 42′ 58″.3	138° 56′ 09″.4
ω =	43 59 37 .5	43 50 52 .8
Ω =	173 10 49 .4	173 07 36 .1
i =	7 13 21 .3	7 13 40 .2
φ =	5 26 15 .2	5 29 58 .5
μ =	952″.3160	952″.3542
log *a* =	0.380817	0.380805

The planet was observed in 1902 as (489) [1902 JO] but the identity is clearly proved by representation of the observations by the above elements which have been corrected for the perturbations by the planet Jupiter.

Asteroid Iris (7) Variable.—A telegram from Professor E. C. Pickering announces that Wendell of Harvard College Observatory finds the asteroid Iris to be variable, with a period of six hours and range of variation of ¼ magnitude

VARIABLE STARS.

Minima of Variable Stars of the Algol Type.

[Greenwich Mean Time beginning with noon. The hours from 12 to 24 are those which occur in the night in the United States. To obtain Eastern Standard time subtract 5 hours; for Central Standard time subtract 6 hours, etc.]

U Cephei.

	d	h
Mar	3	2
	5	14
	8	2
	10	14
	13	2
	15	13
	18	1
	20	13
	23	1
	25	13
	28	0
	30	12

Z Persei

Mar.	4	14
	7	16
	10	17
	13	19
	16	20
	19	21
	22	23
	26	0
	29	1

Algol.

Mar.	1	4
	4	1
	6	22
	9	18
	12	15
	15	12
	18	9
	21	6
	24	3
	26	23
	29	20

λ Tauri.

Mar.	1	21
	5	20
	9	19
	13	17
	17	16
	21	15
	25	14
	29	13

R Canis Maj.

Mar.	1	18
	2	21
	4	0
	5	4
	6	7
	7	10
	8	13
	9	17
	10	20

R Canis Maj.

Mar.	11	23
	13	2
	14	6
	15	9
	16	12
	17	15
	18	19
	19	22
	21	1
	22	4
	23	8
	24	11
	25	14
	26	18
	27	21
	29	0
	30	3
	31	7

RR Puppis

Mar.	5	19
	12	6
	18	16
	25	2
	31	12

V Puppis.

Mar.	1	3
	2	14
	4	1
	5	12
	6	23
	8	10
	9	21
	11	8
	12	19
	14	6
	15	16
	17	3
	18	14
	20	1
	21	12
	22	23
	24	10
	25	21
	27	8
	28	19
	30	5
	31	16

S Cancri

Mar.	5	21
	15	8
	24	20

S Antliæ.

Mar.	1	13
	2	13
	3	12
	4	11
	5	10
	6	10
	7	9
	8	9
	9	8
	10	7
	11	7
	12	6
	13	5
	14	5
	15	4
	16	3
	17	3
	18	2
	19	1
	20	1
	21	0
	21	23
	22	23
	23	22
	24	21
	25	21
	26	20
	27	19
	28	19
	29	18
	30	17
	31	17

S Velorum.

Mar.	6	2
	12	0
	17	23
	23	21
	29	20

W. Urs. Maj.
Period $4^h\ 0^m.2$

Mar. 1-10 11^h

Mar. 11-31 12^h

RR Velorum.

Mar.	2	4
	4	0
	5	21
	7	17
	9	14
	11	10
	13	7

RR Velorum.

Mar.	15	3
	17	0
	18	20
	20	17
	22	13
	24	10
	26	6
	28	3
	29	23
	31	20

Z Draconis.

Mar.	3	22
	5	6
	6	15
	7	28
	9	8
	10	17
	12	1
	13	10
	14	18
	16	3
	17	12
	18	20
	20	5
	21	13
	22	22
	24	6
	25	15
	27	0
	28	8
	29	17
	31	1

δ Librae.

Mar.	2	22
	5	6
	7	13
	9	21
	12	5
	14	13
	16	21
	19	5
	21	13
	23	20
	26	4
	28	13
	30	21

U Coronae.

Mar.	4	7
	7	17
	11	4
	14	15
	18	2

U Coronae.

Mar.	21	13
	25	0
	28	11
	31	21

U Ophiuchi.

Mar.	1	10
	2	6
	3	2
	3	22
	4	19
	5	15
	6	11
	7	7
	8	3
	8	23
	9	19
	10	15
	11	12
	12	8
	13	4
	14	0
	14	20
	15	16
	16	12
	17	9
	18	5
	19	1
	19	21
	20	17
	21	13
	22	9
	23	5
	24	2
	24	22
	25	18
	26	14
	27	10
	28	6
	29	2
	29	22
	30	19
	31	15

R Aræ.

Mar.	3	3
	7	13
	11	23
	16	10
	20	20
	25	6
	29	16

Minima of Variable Stars of the Algol Type.—Continued.

Z Herculis.

	d	h
Mar.	4	2
	5	23
	8	2
	9	23
	12	2
	13	23
	16	2
	17	23
	20	1
	21	22
	24	1
	25	22
	28	1
	29	22

RS Sagittarii.

	d	h
Mar.	2	13
	4	23
	7	9
	9	19
	12	5
	14	15
	17	1
	19	11
	21	21
	24	7
	26	17
	29	3
	31	13

RX Herculis.

	d	h
Mar.	1	15
	2	12
	3	9
	4	7

RX Herculis.

	d	h
Mar.	5	4
	6	1
	6	23
	7	20
	8	17
	9	15
	10	12
	11	9
	12	7
	13	4
	14	1
	14	23
	15	20
	16	17
	17	15
	18	12
	19	9
	20	7
	21	4
	22	2
	22	23
	23	20
	24	18
	25	15
	26	12
	27	10
	28	7
	29	4
	30	2
	30	23
	31	20

RV Lyræ.

	d	h
Mar.	3	12
	7	3
	10	17
	14	7
	17	22
	21	12
	25	3
	28	17

U Sagittæ.

	d	h
Mar.	2	5
	5	14
	8	23
	12	8
	15	17
	19	3
	22	12
	25	21
	29	6

SY Cygni.

	d	h
Mar.	2	15
	8	16
	14	16
	20	16
	26	16

SW Cygni.

	d	h
Mar.	3	1
	7	15
	16	18
	21	8
	25	22
	30	11

WW Cygni.

	d	h
Mar.	2	23
	4	10
	7	21
	12	8

WW Cygni.

	d	h
	15	19
	19	5
	22	16
	26	3
	29	14

W Delphini.

	d	h
Mar.	4	13
	9	8
	14	3
	18	23
	23	13
	28	13

VV Cygni.

	d	h
Mar.	2	9
	3	21
	5	8
	6	20
	8	7
	9	19
	11	6
	12	17
	14	5
	15	16
	17	4
	18	15
	20	3
	21	14
	23	2
	24	13
	26	1
	27	12
	28	23
	30	11
	31	22

VW Cygni.

	d	h
Mar.	2	13
	11	0
	19	10
	27	20

Y Cygni.

	d	h
Mar.	1	5
	2	19
	4	5
	5	19
	7	4
	8	19
	10	4
	11	19
	13	4
	14	19
	16	4
	17	19
	19	4
	20	19
	22	4
	23	19
	25	4
	26	18
	28	4
	29	18
	31	4

UZ Cygni.

	d	h
Mar.	17	14

Maxima of UY Cygni.

Period $13^h\ 27^m\ 21^s$. The minimum occurs $1^h\ 53^m$ before the maximum.

	d	h
Mar.	1	7
	2	9
	3	12
	4	15
	5	18
	6	21
	8	0
Mar.	9	3
	10	6
	11	9
	12	12
	13	15
	14	17
	15	20
Mar.	16	23
	18	2
	19	5
	20	8
	21	11
	22	14
	23	17
Mar.	24	20
	25	22
	27	1
	28	4
	29	7
	30	10

Maxima of Y Lyræ.

Period $12^h\ 03.9^m$. The minimum occurs $1^h\ 40^m$ before the maximum.

	d	h
Mar.	1	10
	2	10
	3	10
	4	10
	5	11
	6	11
	7	11
	8	11
Mar.	9	11
	10	11
	11	11
	12	11
	13	12
	14	12
	15	12
	16	12
Mar.	17	12
	18	12
	19	12
	20	12
	21	13
	22	13
	23	13
	24	13
Mar.	25	13
	26	13
	27	13
	28	13
	29	13
	30	13
	31	13

Variable Stars of Short Period not of the Algol Type.

	Minimum.		Maximum.			Minimum.		Maximum.	
	d	h	d	h		d	h	d	h
T Crucis	Mar. 1	0	Mar. 3	1	W Sagittarii	Mar. 14	17	Mar. 17	17
Y Sagittarii	1	1	2	20	SU Cygni	15	2	16	10
T Vulpeculae	1	16	5	2	ζ Geminorum	15	7	20	7
S Sagittæ	1	18	2	17	S Normae	16	5	20	15
V Velorum	1	21	5	8	δ Cephei	16	13	17	22
S Muscae	1	22	8	3	V Centauri	16	21	18	8
X Cygni	1	4	2	13	T Velorum	16	23	18	8
T Velorum	3	1	4	10	U Sagittarii	17	17	20	16
κ Pavonis	3	11	7	6	V Carinae	17	19	19	23
SU Cygni	3	13	4	21	S Triang.Austr.	17	20	19	22
U Sagittarii	4	5	7	4	R Crucis	17	23	19	8
U Vulpeculae	4	7	6	10	X Cygni	18	7	24	12
V Carinae	4	9	6	11	Y Sagittarii	18	8	20	3
S Crucis	4	23	6	11	RV Scorpii	18	9	19	19
ζ Geminorum	5	3	10	3	S Sagittae	18	11	21	21
S. Triang. Austr.	5	4	7	6	β Lyrae	18	17	22	0
T Vulpeculae	5	15	7	0	SU Cygni	18	22	20	6
X Sagittarii	5	15	8	12	T Vulpeculae	18	22	20	13
δ Cephei	5	19	7	4	S Crucis	19	1	20	7
U Aquilae	5	19	7	23	V Velorum	19	6	20	5
β Lyræ	5	19	9	2	X Sagittarrii	19	16	22	13
V Centauri	5	21	7	8	U Aquilae	19	20	22	0
V Velorum	6	3	7	2	U Vulpeculae	20	6	22	9
RV Scorpii	6	6	7	16	S Muscae	21	5	24	16
R Crucis	6	7	7	16	T Crucis	21	11	23	12
S Normae	6	11	10	21	T Velorum	21	14	22	23
Y Ophiuchi	6	12	9	3	κ Pavonis	21	16	25	11
W Geminorum	6	11	12	16	η Aquilae	21	18	24	3
Y Sagittarii	6	19	8	14	δ Cephei	21	22	23	7
W Sagittarii	7	2	10	2	W Geminorum	22	0	24	15
SU Cygni	7	9	8	17	W Sagittarii	22	7	25	7
η Aquilae	7	16	9	1	V Centauri	22	9	23	20
T Velorum	7	17	9	18	SU Cygni	22	18	24	2
T Crucis	7	9	9	18	T Vulpeculae	23	9	24	18
S Crucis	9	16	11	4	Y Ophiuchi	23	13	24	18
T Vulpeculae	10	1	11	10	V Velorum	23	15	29	14
S Sagittae	10	1	13	11	R Crucis	23	18	25	3
V Velorum	10	12	11	11	S Crucis	23	18	25	6
U Sagittarii	10	23	13	22	S Triang. Austr.	24	4	26	6
V Carinae	11	3	13	7	V Carinae	24	12	26	16
δ Cephei	11	4	12	13	Y Sagittarii	24	4	25	23
SU Cygni	11	6	12	14	RV Scorpii	24	10	25	20
V Centauri	11	9	12	20	U Sagittarii	24	11	27	10
W Virginis	11	12	—	—	β Lyrae	25	4	28	6
S Trianguli Austr.	11	12	13	5	ζ Geminorum	25	10	30	10
S Muscae	11	13	15	1	S Normae	25	23	30	9
R Crucis	12	3	13	12	T Velorum	26	6	27	15
U Vulpeculae	12	6	14	9	SU Cygni	26	15	27	23
β Lyrae	12	6	15	8	X Sagittarii	26	16	23	13
TX Cygni	12	7	17	10	U Aquilae	26	20	29	0
T Velorum	12	7	13	16	S Sagittae	26	20	30	6
RV Scorpii	12	7	13	17	TX Cygni	27	1	32	4
κ Pavonis	12	13	16	8	δ Cephei	27	6	28	15
Y Sagittarii	12	14	14	9	T Vulpeculae	27	19	29	4
X Sagittarii	12	15	15	12	T Monocerotis	27	20	35	18
U Aquilae	12	19	14	23	V Centauri	27	21	29	8
V Velorum	13	21	14	20	T Crucis	27	22	29	23
W Geminorum	14	6	16	21	V Velorum	27	23	28	22.
S Crucis	14	9	15	21	U Vulpeculae	28	5	30	8
T Crucis	14	12	15	21	S Crucis	28	10	29	22
T Vulpeculae	14	11	16	12	W Virginis	28	18	—	—
η Aquilae	14	13	16	22	η Aquilae	28	22	31	7

Variable Stars of Short Period not of the Algol Type.—Continued.

	Minimum.		Maximum.			Minimum.		Maximum.	
	d	h	d	h		d	h	d	h
R Crucis	Mar. 29	14	30	23	κ Pavonis	Mar. 30	21	32	6
W Geminorum	29	18	32	9	T Velorum	30	21	34	8
W Sagittarii	29	21	32	21	S Muscae	30	18	34	13
Y Sagittarii	29	22	31	17	T^3 Cygni	30	23	32	7
S Triang. Austr.	30	11	32	13	U Sagittarii	31	4	34	3
RV Scorpii	30	12	31	22	β Lyrae	31	15	34	22

Approximate Magnitudes of Variable Stars Jan. 10, 1904.

[Communicated by the Director of Harvard College Observatory, Cambridge, Mass.]

Name.	R. A. 1900. h	m	Decl. 1900. °	′	Magn.	Name.	R. A. 1900. h	m	Decl. 1900. °	′	Magn.
T Androm.	0	17.2	+26	26	*f*	R Camel.	14	25.1	+84	17	11*d*
T Cassiop.	0	17.8	+55	14	8*i*	R Bootis	14	32.8	+27	10	*f*
R Androm.	0	18.8	+38	1	8*i*	S Librae	15	15.6	−20	2	*u*
S Ceti	0	19.0	− 9	53	12*d*	S Serpentis	15	17.0	+14	40	*f*
W Cassiop.	0	49.0	+58	1	*u*	S Coronae	15	17.3	+31	44	10*i*
S "	1	12.3	+72	5	13*d*	S Urs. Min.	15	33.4	+78	58	7
R Piscium	1	25.5	+ 2	22	12*d*	R Coronae	15	44.4	+28	28	6
R Trianguli	1	31.0	+33	50	7*d*	V "	15	45.9	+39	52	*u*
U Persei	1	52.9	+54	20	8*d*	R Serpentis	15	46.1	+15	26	*u*
R Arietis	2	10.4	+24	36	8	R Herculis	16	1.7	+18	38	9*d*
o Ceti	2	14.3	− 3	26	8*i*	R Scorpii	16	11.7	−22	42	*s*
S Persei	2	15.7	+58	8	10*d*	S "	16	11.7	−22	39	*s*
R Ceti	2	20.9	− 0	38	13*d*	U Herculis	16	21.4	+19	7	*u*
U "	2	28.9	−13	35	13*d*	R Ursae Min.	16	31.3	+72	28	*u*
R Persei	3	23.7	+35	20	*u*	W Herculis	16	31.7	+37	32	9*i*
R Tauri	4	22.8	+ 9	56	9*i*	R Draconis	16	32.4	+66	58	*u*
S "	4	23.7	+ 9	44	15*f*	S Herculis	16	47.4	+15	7	9*d*
R Aurigæ	5	9.2	+53	28	8*i*	R Ophiuchi	17	2.0	−15	58	9*d*
U Orionis	5	49.9	+20	10	12*d*	T Herculis	18	5.3	+31	0	10*d*
R Lyncis	6	53.0	+55	28	10*d*	R Scuti	18	42.2	− 5	49	*s*
R Gemin.	7	1.3	+22	52	11*d*	R Aquilae	19	1.6	+ 8	5	*u*
S Canis Min.	7	27.3	+ 8	32	8*i*	R Sagittarii	19	10.8	−19	29	*s*
R Cancri	8	11.0	+12	2	9*d*	S "	19	13.6	−19	12	*s*
V "	8	16.0	+17	36	12*i*	R Cygni	19	34.1	+49	58	9*d*
S Hydrae	8	48.4	+ 3	27	8*i*	RT "	19	40.8	+48	32	*f*
T "	8	50.8	− 8	46	9*i*	X "	19	46.7	+32	40	7*d*
R Leo. Min.	9	39.6	+34	58	9*d*	S Cygni	20	3.4	+57	42	*f*
R Leonis	9	42.2	+11	54	9*d*	RS "	20	9.8	+38	28	7
R Urs. Maj.	10	37.6	+69	18	13*d*	R Delphini	20	10.1	+ 8	47	13*f*
R Comae	11	59.1	+19	20	*f*	U Cygni	20	16.5	+47	35	9*i*
T Virginis	12	9.5	− 5	29	11*i*	V "	20	38.1	+47	47	12*i*
R Corvi	12	14.4	−18	42	8*i*	T Aquarii	20	44.7	− 5	31	8*i*
Y Virginis	12	28.7	− 3	52	10*i*	R Vulpec.	20	59.9	+23	26	10*d*
T Urs. Maj.	12	31.8	+60	2	11*d*	T Cephei	21	8.2	+68	5	7*i*
R Virginis	12	33.4	+ 7	32	9*i*	S "	21	36.5	+78	10	7*i*
S Urs. Maj.	12	39.6	+61	38	11*d*	S Lacertae	22	24.6	+39	48	*u*
U Virginis	12	46.0	+ 6	6	9*d*	R "	22	38.8	+41	51	13*f*
V "	13	22.6	− 2	39	9*i*	S Aquarii	22	51.8	−20	53	13*f*
R Hydrae	13	24.2	−22	46	8*i*	R Pegasi	23	1.6	+10	0	12*d*
S Virginis	13	27.8	− 6	41	9*d*	S "	23	15.5	+ 8	22	9*i*
R Can. Ven.	13	44.6	+40	2	*f*	R Aquarii	23	38.6	−15	50	8*i*
S Bootis	14	19.5	+54	16	8*d*	R Cassiop.	23	53.3	+50	50	7*i*

NOTE:—*f* denotes that the variable is probably fainter than the magnitude 13; *i*, that its light is increasing; *d*, that its light is decreasing; *s*, that it is near the Sun; *u*, that its magnitude is unknown.

Derived from observations made at the Halsted, McCormick, Eadie, Vassar College and Harvard Observatories, Jan. 10, 1904.

Change in the Time Used in the Variable Star Tables.—At the urgent request of some of the variable star observers we have decided to give the variable star data in Greenwich Mean Time (Astronomical) instead of Greenwich Civil Time as we have done for the past three years. Heretofore we have taken much of the data from the "Companion to The Observatory" and the "Annuaire du Bureau des Longitudes" which use civil time, and to guard against errors we preferred not to convert the time into astronomical time. Now our plan will be to compute the tables entirely from the latest available elements. This month the minima of the Algol Type variables have been independently computed from the Revised Elements just published by Chandler, so far as they applied, and from the best elements we could find for the stars not in Chandler's list. We hope variable star observers will inform us promptly of any errors and of improved elements which may be used.

Revision of the Elements of Chandler's Third Catalogue of Variable Stars.—In the *Astronomical Journal* No. 553 Mr. S. C. Chandler gives the results of a revision of the elements of the stars contained in his *Third Catalogue of Variable Stars* (*A. J.* 379), utilizing all the suitable material for that purpose that has been published since that Catalogue was issued.

New Variable Star 62.1903 Andromedæ.—This is the star BD + 43°.462, R. A. $2^h\ 8^m\ 37^s.2$ + 43° 37′.5 (1855.0) and is a companion to the variable W Andromedae, which it follows by $11^s.6$ on the same parallel. Father J. G. Hagen, S. J., of the Georgetown College Observatory, gives, in *A. N.* 3917, 10 observations of this star in 1900-1903, which tend to show that its light varies from 9.9 to 8.8, probably in a long period. The color of the star is reddish yellow.

New Variable Star 63.1903 Lyræ.—Rev. T. D. Anderson announces this in *A. N.* 3920. It is not found in the BD. but its approximate position for 1855 is

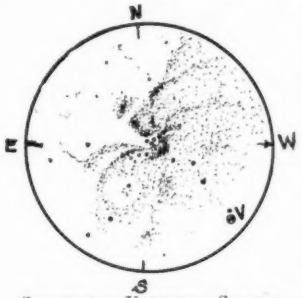
R. A. $19^h\ 08^m.8$; Decl. + 46° 43′.

"On Nov. 2 1903 it was of the 9.2 magnitude, but on Dec. 6 it was only $10^m.1$ and on Dec. 14 $10^m.3$. These values have been arrived at on the assumption that BD. + 46°.2649, 2650 and 47°.2789 are $10^m.1$, $9^m.5$ and $8^m.4$ respectively, and that a star not inserted in the BD. which lies about 2′ to the s. f. of + 46°.2649 is $10^m.5$. It may be mentioned that + 46°.2649 precedes by about 15^s the place in which it is laid down on the BD. chart."

The Variable Star ε Aurigæ.—In *A. N.* 3918-20 Mr. H. Ludendorff gives the results of an extensive study of the light changes of this star which has been known for many years as an irregular variable. His conclusion is that ε Aurigæ is a variable of the Algol type but of the very long period of 9905 days or 27.12 years. As a rule its magnitude is 3.35; in falling to minimum it occupies 207 days and declines about 0.73 of a magnitude. It remains constant at minimum for about 313 days and then in 207 days rises to its former brightness. After that it remains at its ordinary magnitude for 25.13 years. Mr. Ludendorff has made use of the observations of fifteen reliable observers covering pretty

completely the period from 1842 to 1903. He admits that that duration of the decline and increase, as well as of the period of constancy at minimum, are somewhat uncertain. The latter may be greater than 313 days and the former may be less than 207 days. The spectrum of the star shows that it consists of two bright bodies and it may be that the real period is 54¼ years instead of 27.12. The next minimum should occur in the years 1928-30.

Suspected Variable in the Orion Nebula.—Mr. Chas. P. Foster of Waterloo, Ia., calls attention to a star in the Orion nebula, marked V in the accompanying sketch. Ordinarily it seems considerably brighter than the companion star, just above it in the sketch, but upon the nights of March 7, 1896, Jan. 28, and Jan. 29, 1897, it seemed fainter than usual. On the last mentioned night the two stars were noted as equal in brightness.



SUSPECTED VARIABLE STAR IN THE ORION NEBULA.

The star is BD — 5°,1301 mag. 9.1 and its position for 1855 is

R. A. $5^h\ 27^m\ 26^s.9$; Decl. — 5° 49′.0

It is not a known variable, although there is a list of over 20 variables in the Nebula of Orion. On seven or eight photographs of the Nebula taken at Goodsell Observatory the star shows no variation, being always brighter than the neighboring star BD — 5°,1303.

U Orionis.—The enclosed charts represent the light curve of the variable star U Orionis ($\alpha = 5^h\ 49^m\ 54^s$, $\delta = +\ 20°\ 10'\ 0''$) based upon observations taken here from December 31st, 1901 to May 17th, 1902 and from February 23d, 1903 to May 14th, 1903, by the Argelander method. This is the variable that was discovered by Gore in Ireland on December 13th, 1885, and at first was thought to be a Nova. Its period seems to vary from about 360 to 377 days. The maxima vary from 5.9 magnitude to 6.3 magnitude, but the minima are all near 12.5 magnitude. According to my observations the 1902 maximum occurred about May 5th, the star rising to 5.9 magnitude whereas the 1903 maximum occurred about April 27th, the star rising to only 6.28 magnitude. This is one of the long period variables that resembles *o* Ceti in many ways. It has a spectrum of Secchi's third type, and is very red in color especially near its maximum brightness.

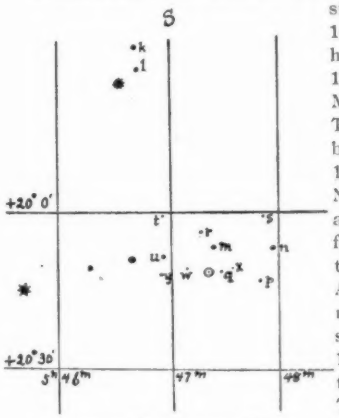
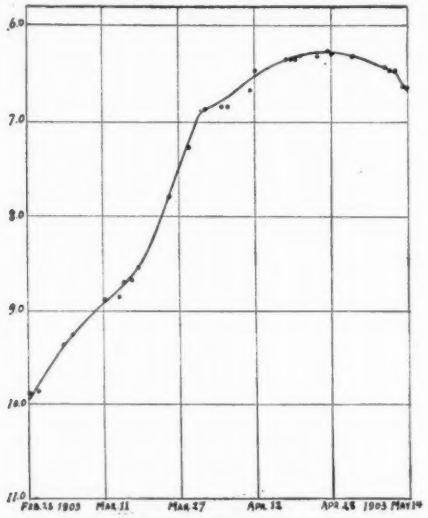
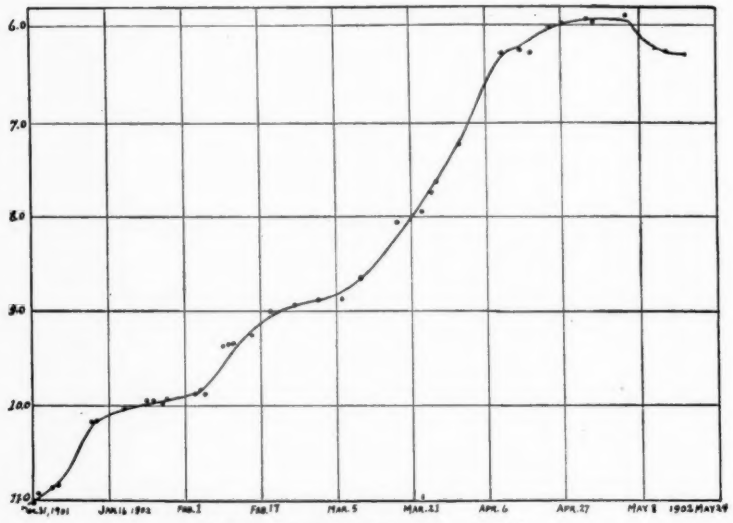


CHART OF COMPARISON STARS FOR U ORIONIS.



LIGHT CURVE OF U ORIONIS IN 1903.



LIGHT CURVE OF U ORIONIS IN 1902.

OBSERVATIONS OF U ORIONIS.

75th Meridian Time.					J. Day.	Comparison.	
y	m	d	h	m			
1901	12	31	8	50	2415750	Var = s	
1902	1	1	10	5	5751	r3VV½s	Clouds.
	"	4	9	50	5754	r2½VV1s	
	"	5	9	10	5755	r2VV1s	
	"	12	8	25	5762	Var = q	
	"	13	8	20	5763	Var = q	
	"	19	7	40	5769	p2½VV½q	
	"	24	8	50	5774	p2VV1½q	
	"	25	8	10	5775	p2VV1½q	
	"	27	8	35	5777	p2VV1q	
	"	28	8	10	5778	p1½VV1½q	
	2	3	8	55	5784	p1VV2q	
	"	4	7	35	5785	p½VV2q	
	"	5	10	15	5786	p1VV2q	
	"	9	7	45	5790	n1½VV½p	
	"	10	7	20	5791	n1½VV1p	
	"	11	8	0	5792	n1½VV1p	
	"	15	9	0	5796	n½VV2p	
	"	19	6	45	5800	Var = n	
	"	24	8	10	5805	m2VV2½n	
	3	1	8	15	5810	m2VV3n	
	"	6	8	30	5815	Var = m	
	"	10	8	20	5819	l3VV1½m	
	"	18	7	25	5827	k½VV1½l	
	"	23	8	20	5832	Var = k	
	"	25	7	55	5834	h1½VV2k	
	"	26	8	10	5835	Var = h	
	"	31	7	30	5840	g½VV2½h	
	4	9	7	55	5849	e1½VV2f	
	"	13	7	40	5853	e1½VV2½f	
	"	15	7	45	5855	e1½VV2f	
	"	19	7	35	5859	Var = e	
	"	22	7	45	5862	d2VV½e	
	"	27	8	5	5867	d1½VV1e	
	"	28	8	0	5868	d2VV½e	
	5	5	8	20	5875	d1½VV1½e	
	"	11	7	45	5881	e1VV2½f	Twilight.
	"	13	7	40	5883	e1VV2f	"
	"	17	8	10	5887	e1VV1½f	
1903	2	23	9	25	2416169	p1VV1½q	
	"	25	7	55	6171	p1VV2q	
	3	1	7	55	6175	p1VV2q	
	"	2	7	45	6176	n1½VV½p	
	"	4	7	45	6178	n½VV2p	
	"	11	9	25	6185	m1½VV2½n	
	"	14	7	50	6188	Var = m	
	"	15	8	50	6189	l3VV½m	
	"	17	7	55	6191	e2½VV1½m	
	"	18	7	25	6192	l2VV2m	
	"	25	7	55	6199	h1½VV1k	
	"	29	7	15	6203	g1½VV2½h	
	"	31	7	35	6205	f2½VV1½g	
	4	1	7	35	6206	f3VV1½g	
	"	5	7	45	6210	f2VV2½g	
	"	6	7	10	6211	f2VV2½g	
	"	11	7	30	6216	f1VV4g	
	"	12	7	20	6217	e3½VV½f	
	"	18	7	20	6223	e2½VV2f	
	"	19	7	35	6234	e2½VV1½f	
	"	20	7	35	6225	e2½VV1½f	

OBSERVATIONS OF U ORIONIS.—Continued.

75th Meridian Time.					J. Day.	Comparison.	
y	m	d	h	m			
1903	4	21	7	5	2416226	e2VV2f	Twilight.
	"	25	7	25	6230	e2VV2f	"
	"	27	7	25	6232	e1½VV2½f	"
	"	28	7	35	6233	e2VV2½f	"
	5	2	7	20	6237	e2VV2f	
	"	9	7	40	6244	e3VV1f	"
	"	10	7	35	6245	e3½VV1f	"
	"	11	7	45	6246	e3½VV1f	"
	"	12	7	45	6247	e4VV1f	Poor obs.
	"	13	8	10	6248	Var = f	"

F. E. SEAGRAVE.

PROVIDENCE, Dec. 16th, 1903.

GENERAL NOTES.

Meeting of the Astronomical and Astrophysical Society of America, at St. Louis, Dec. 29-30, 1903.—The Society met in affiliation with Section A (Astronomy and Mathematics) of the American Association for the Advancement of Science in one of the rooms of the central high school building at St. Louis. The attendance was smaller than usual and the program was short. The officers elected for the ensuing year were

President:	Simon Newcomb
Vice Presidents:	George E. Hale W. W. Campbell
Treasurer:	C. L. Doolittle
Councillors:	E. C. Pickering R. S. Woodward

The permanent Secretary is Geo. C. Comstock, Director of Washburn Observatory, Madison, Wis.

The following papers were presented, nearly all being read in full. Several of the writers were not present, but their papers were read by others.

1. On the Rotation Period of Saturn. G. W. Hough, Dearborn Observatory.
2. The Prediction of Occultations of Stars by the Moon. G. W. Hough.
3. The D. O. Mills Expedition. W. W. Campbell, Lick Observatory.
4. The Sun's Motion Relative to a Group of Faint Stars. G. C. Comstock, Washburn Observatory.
5. The Absorption of Solar Radiation by the Sun's Atmosphere. F. W. Very, Washington, D. C.
6. Facilities for Astronomical Photography in Southern California. E. L. Larkin, Lowe Observatory.
7. Borrelly's Comet *c* 1903. Sebastian Albrecht, Lick Observatory.
8. The Pivots of the 9-inch Transit Circle of the U. S. Naval Observatory. W. S. Eichelberger, U. S. Naval Observatory.
9. The Supporting and Counterweighting of the Principal Axes of Large Telescopes. C. D. Perrine, Lick Observatory.
10. A Short Sketch of the Progress of Astronomy in the United States. M. S. Brennan, St. Louis, Mo.

11. The Eros Parallax Photographs at Goodsell Observatory. H. C. Wilson, Goodsell Observatory.

12. A New Type of Transit-Room Shutter. D. P. Todd, Amherst College Observatory.

The roster of members present was: Simon Newcomb, Washington, D. C,, R. S. Woodward, Columbia College, New York, Ormond Stone, Leander McCormick Observatory, Geo. C. Comstock, Washburn Observatory, W. S. Eichelberger, U. S. Naval Observatory, Chas. S. Howe, Case School of Applied Science, Cleveland, O., Joel Stebbins, Urbana, Ill., L. G. Weld, University of Iowa, O. H. Tittmann, U. S. Coast Survey, Washington, D. C., H. C. Wilson, Goodsell Observatory, Martin S. Brennan, St. Louis, A. Lawrence Rotch, Boston, Mass., G. W. Hough, Dearborn Observatory, Edgar L. Larkin, Lowe Observatory.

A Fine Conjunction.—On the 20th of December, 1903, the lovers of the sky had the opportunity to observe a fine spectacle. Reddish Mars and pale Saturn met as good friends and almost shook hands. In the city of Mexico the phenomenon was visible in clear atmospheric conditions. About half past six in the evening, with the sky of a violet color, something like the color of the

vapor of iodine, the two beautiful planets, Mars and Saturn, shone finely in the southwest. Even persons who have no knowledge of the beauties of astronomy noted that friendly meeting. It was a fine view, indeed. As the sky became darker, the view grew finer. Unfortunately, soon after, the two planets were lost in the mist of the horizon. PROF. LUIS G. LEON.

MEXICO CITY, December 21st, 1903.

Dr. Swift's Perpetual Calendar.—Dr. Lewis Swift, late Director of the Mt. Lowe Observatory, California, and now of Marathon, N. Y., has recently sent me a model of a perpetual calendar, invented by himself. It is adjustable, one side to any date in the 18th or 19th century, the other side to any date in the 20th century. Even the leap years are fully provided for. At the center a revolving disc has for its circumference the days of the week, four times repeated; in columns with these, leading toward the center of the disc, appear the various years of the century, properly arranged, with a blank immediately preceding each leap year. Above, in columns to match these are properly distributed the names of the months; below, in similar columns are arranged the numerals for the 30 days of the month. To ascertain the day of the week on which one was born, place the year of his birth in the column with the month of his birth, and at the bottom the day of the month will be found in the column with the day of the week. Thus I ascertain that one born July 1st, 1850, was born on Monday. Dr. Swift, himself, a leap year baby, born on Feb. 29, 1820, was born on Wednesday. Looking ahead, he will celebrate his 20th birthday, but the completion of his 84th year, on Tuesday, Feb. 29, 1904. Thus the calendar, so ingeniously contrived, works in both directions. Whether or not it is Dr. Swift's intention to have these prepared for general use, I have not learned. FREDERICK CAMPBELL.

BROOKLYN, N. Y.

Insertion.—Page 78, eighth line from bottom insert: "The photograph was taken September 2, 1901, 11.3 days after sunrise, colongitude 149°. While therefore it was taken about three days later in the lunation than the drawing, still it does not show any very marked changes to have occurred in the mean time, excepting possibly in the relative intensity of some of the canals.

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